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THE SNOW PEAKS OF THEOPHILUS.

WILLIAM H. PICKERING.

This well-known lunar crater is situated in longitude 334° and latitude — 11°. Its diameter according to Neison is 64 miles (102 km). He states that the western rim rises 18,000 feet (5,400 metres) above the floor, while the central peaks rise to an altitude of about 5,600 feet (1,700 metres). It is to these latter that we shall devote our special attention. They form a group of summits, the circumference of whose base describes an irregular circle some 10 miles (16 km) in diameter. As pointed out in my recent paper, "Evidences of Erosion on the Moon", Popular Astronomy 1916, **24**, 441, these peaks seem to be but the vestiges of a once great smooth central cone, whose sides were grooved by glacial action, which scored them with a series of U-shaped valleys into their present deeply eroded form. Two of these valleys opening towards the north, and one towards the west, are well shown in the excellent photograph by Ritchey taken at about colongitude 145° with the 40-inch Yerkes refractor. Even the lateral moraines, stretching slightly to the west of north across the floor, are faintly shown upon it.

The glaciers which once filled these valleys have long since disappeared, but the névé or upper snowy area whence they sprang is still readily visible with even a small telescope, and it is to its changing form and brightness under the influence of the direct solar rays to which we shall especially direct our attention. Sunrise on the peaks occurs at colongitude 334°, or rather would do so were it not for the high outer rim of the crater, which delays it about 1°. This would indicate an altitude of 14,000 feet for the western wall, instead of 18,000 as given above. Noon occurs at 64°, and sunset at 154°. The fundamental data relating to the nine drawings shown in the accompanying plate (page 150) are given in Table I.

FIGURE 1.
345°.1

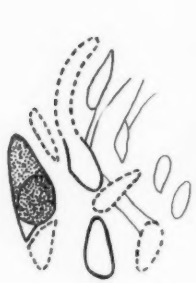


FIGURE 2.
354°.0

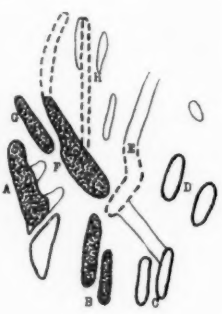


FIGURE 3.
22°.6

FIGURE 4.
48°.0

FIGURE 5.
72°.4

FIGURE 6.
87°.3

FIGURE 7.
100°.2

FIGURE 8.
111°.5

FIGURE 9.
127°.9

AREAS OF SNOW AND CLOUD IN THEOPHILUS.

TABLE I.

DESCRIPTION OF THE DRAWINGS.

No.	Date	Colong.	Diff.	Magn.	Seeing
		°	°		
1	1916 Feb. 9	345.6	8.9	330	8
2	1915 Nov. 13	354.0	28.6	330	7
3	" Dec. 15	22.6	25.4	330	7
4	" " 17	48.0	24.4	330	12
5	" " 19	72.4	14.9	330	8 to 6
6	" " 20	87.3	12.9	430	12
7	" Oct. 23	100.2	11.3	330	10
8	" " 24	111.5	16.4	330	8
9	1916 Sept. 14	127.9		330	8

Under a low Sun the shadows of the peaks are their most conspicuous feature, but they have been omitted in the drawings since they would merely confuse the reader, only the details of the peaks and the outlines of the bright areas being shown. Under a high Sun only the bright areas are visible. Those regions having about the same brightness as the floor under full illumination, let us say 5 on the scale of brightness, are represented by fine lines and indicate bare rock, peaks and ridges. Areas that are somewhat brighter, as 6, have their outlines dotted in heavier lines. Still brighter areas, 7, are shown in full heavy lines. These areas are probably cloud of varying density. Still brighter areas, 8 and 9, are shaded and indicate areas more or less covered with cloud and snow, while the brightest areas, 10, are blackened, and it is thought represent fields of unbroken fresh-fallen snow. It has proved rather difficult to represent the positions, orientation, and proportions of some of the fainter and more hazy of these areas accurately, since not only are they all extremely small, but it is clear that they also are constantly changing, and there are no fixed markings, such as small craters or cracks, suitable to serve as points of reference. Nevertheless it is believed that a fair degree of accuracy has been attained, and that no great improvement is at present possible. It is reasonably certain that the white areas exhibit slight changes of shape at the same colongitudes during different lunations. The scale of the drawings is 8 miles or 7″ to the inch (5 kilometers or 2″.8 to the centimeter). In Figure 3 the different groups of bright areas are lettered. Group *A* is the highest and group *F* the next. *A* is much the most interesting group to watch because not only are its changes very marked, but it is the brightest of the various groups, and its outlines are therefore more distinctly seen. In Figure 1 the central portion of the large mass is clearly the brightest, next the portion lying directly south of it, while the northern area is comparatively faint, carrying little if any snow or cloud. As the lunation proceeds all three areas

become brighter, but the northern one lags. By colongitude 48° it nearly equals the other two, but it is not until colongitude 100° that it fully catches up with them. Its brightness is then 9.

At colongitude 355° two small U-shaped ravines may be detected on the south-eastern side of *A*. They are indicated in Figure 3. The intervening ridges are faint, but between 25° and 35° they suddenly brighten and become very conspicuous, giving the southern portion of *A* a shape something like a letter E. In Figure 4 a small circular area distinctly brighter than the rest is seen. This it is thought is due to freshly fallen snow, precipitated from moisture given out by a small invisible crater. This crater proves to be at the extreme summit of the formation, but it is so small or indistinct, or both, that the writer has never been able to detect it. It is nearly in the center of Theophilus, and doubtless indicates the site of the primary summit and crater long since vanished. It is the only permanently bright area situated upon the peaks, and is too small to form a true glacier. Other bright points in the immediate vicinity soon appear, but the lines connecting them grow thinner and thinner and finally break and vanish. These changes occur at just about the time of full Moon, colongitude 85° to 95°, and it would be of interest to watch this region at the time of a lunar eclipse and see how, if in any way, it was affected by the temporary withdrawal of the Sun's rays.

Such an opportunity occurred this past January 7, but unfortunately the seeing here was poor that night, only 5 and 6 on the standard scale, so that practically nothing could be done. The next night the seeing was better, 10 and 9, and it was noticed that the white areas on the eastern slopes, *D* and *E*, which at this colongitude should be diminishing in brightness, were brighter and more pronounced than usual. No change was detected in the western areas. Another, although much less favorable eclipse occurs next July, when it is hoped that better conditions may prevail.

The Sun passes the meridian of the crater, which is their midsummer, as we have seen, at 64°, and as it begins to sink lower in the east* the bright areas, having passed their minimum size, now again broaden, and gradually assume a shape approximating to that which they displayed at sunrise. At 140° the appearance has changed but little from that shown in the last figure, but a rather crude drawing made at 150°, just before *A* disappeared, shows it with practically the same form as that shown in Figure 1. Little change therefore occurs during the long cold night.

Region *F*, the second highest area, gradually decreases in size as the

* The terms east and west are reversed on the Moon by astronomers.

lunation progresses, reaching a minimum about noon in Figure 5, and then gradually increases again. While it is growing smaller it is also growing brighter, reaching a maximum of 9 in Figure 4, and again becoming fainter and reaching a second maximum of 8 in Figure 9. Region *G* undergoes a somewhat similar change. Region *C* exhibits a curious phenomenon. Like *B* it shows at first in Figures 1, 3 and 4 two elongated parallel areas side by side. In Figure 5 these have merged into one, but in Figures 6 and 7 it has again divided, this time into two approximately circular areas lying nearly north and south of one another. The earlier appearance is confirmed by six other drawings made at about the same colongitude, the second by two, and the third also by two others. The limiting colongitudes hitherto observed for the first appearance are 345° and 50°, for the second 67° and 72°, and for the third 87° and 100°. Prior to 345° and after 111° it appears single and rather faint. It reaches its maximum brilliancy 7, in Figures 3 and 4. It would seem as if there could be but little doubt that the brightest regions shown in these drawings owe their brilliancy to snow. In order to withstand the evaporation due to a tropical sun, unprotected by any appreciable atmosphere, in latitude 11°, this snow must be rather deep, even if it is being constantly renewed from the Moon's interior. It must be remembered that none of the bright lines shown can be less, allowing for irradiation, than 50 to 100 yards in width, and none of the circles much less than half a mile. In a rough and jagged region there would be many small steep areas where snow would not lie, but which would become visible to us only, on account of their small size, by a diminution of the general brilliancy of the whole area. We might naturally expect therefore that some snowy areas would appear to be brighter than others.

On the other hand some of the circles, in whose centers we believe are located minute craterlets, are over a mile in diameter, and snow could not reach their circumferences except through the atmosphere, forming thus a cloud of minute ice crystals. Even on the Moon, in the absence of any supporting atmosphere, such crystals would fall by gravity alone too rapidly to reach such a distance unless they were projected with very improbable velocities. Moreover although often carefully searched for, the writer has found no evidence of any cloud rising as much, let us say, as a quarter of a mile above the Moon's surface. This would seem to eliminate projection as a possible means of transportation. There remains atmospheric diffusion, electrical repulsion, and the repulsion of light. The forms of some of our high cirrus clouds, known as mare's tails, are supposed to be due in part to electrical action, and we can well believe that ice crystals escaping from a crater might become charged electrically, as is the case with

water drops in the old experiment of the hydro-electrical machine, and be transported until gravity exceeded the repulsive effect of the diminishing electrical charge. However this may be, these changing snow areas seem necessarily to involve the existence of low cloud or fog in some form or other, and thin clouds doubtless account for some of the less brilliant areas observed.

In this connection it may be pointed out that the observation of occultations at Greenwich and elsewhere does actually indicate the existence of a rare atmosphere, which can otherwise only be explained away by irradiation. How dense this atmosphere may be we have no means of knowing, since the refractive power of an atmosphere when the mean path of a molecule is large is unknown. Moreover there is no serious theoretical objection to a rather rare lunar atmosphere composed largely of heavy gases like argon, krypton, and xenon, or even of a lighter gas like carbon dioxide, if it is constantly renewed from the Moon's interior.

A very casual examination of the Moon will show that under high illumination nearly half of the craters exhibit white patches on portions of their interior slopes. Very little attention has ever been paid to them by selenographers. They are sometimes visible as soon as the Sun rises upon them, but more often they gradually develop under the action of the solar rays. They lie on the slopes most directly exposed to the Sun, and as the Sun moves across the lunar sky, they shift from the eastern to the western side of the craters. In the southern hemisphere they circle round the crater by way of the south, and in the northern by way of the north. Even quite near the equator the circling occurs to a certain extent. The whiteness is frequently due to small irregularly shaped bright areas, which are sometimes related to small craters, but more often they lie on some steeply inclined interior slope. They rarely occur on the outer slopes of the craters.

It seemed that it would be of interest to determine between what longitudes on any given date the two sides of the craters were equally bright, and then determine the relation of these longitudes to the position of the Sun. This can only be done on a few days on either side of full moon, since we can only properly judge the brightness of those craters that are located near the center of the disk. It was decided to limit the observations therefore to dates when the colongitude lay between 60° and 120°. Observations were made on five successive nights last December and on five nights in January. It was found that on the average the craters were equally illuminated at $3°.3 \pm 3°.2$ before the Sun reached their meridian. That is, assuming the deviation real, at lunar noon or midsummer for any given crater, the melting is going on slightly faster than the formation of the snow.

TABLE II.

WHITE SPOTS ON THE RIM OF THEOPHILUS.

1916	Colongitude	a	b	c	d	e	f	g
	°							
Nov. 30	342.8	9	8.7					
Dec. 1	355.1	9	8					
" 2	6.2	7,8	7.5	7				
" 3	18.4	7,8	7.5	7	7			
" 4	31.7	8	8	8	7.5			
" 5	43.1	8	8	8	7.5			
" 6	54.9	8	7	7.5	7			
" 7	67.8	8	6	7	7	7	6	7
" 8	80.7		6	7	7	7	7	7
" 9	93.1			7	7	8	8	8
" 10	105.4				6	7	8	8
" 11	118.3				6	7	7	7
" 12	130.1					7	7	7
" 13	142.2					6	7	7

A special study of these spots has been made in the case of two craters, Theophilus and Plinius. For the former their positions and shapes are shown in Figure 10, but only a portion of them are usually visible at the same time, and their sizes are constantly changing. A

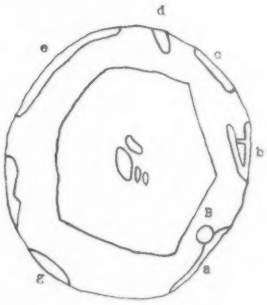


FIGURE 10.

THEOPHILUS.

study of their changes in brightness on the fourteen nights of their visibility last December is given in Table II. The circling nature of their development is there clearly shown in connection with the Figure, the direction of rotation being from north towards the east. Except in the case of the first two, they reach their maximum brilliancy in a couple of days after their first appearance, and then gradually fade out. Nine nights is the maximum duration of any of them, seven the minimum. Whether they are due to snow or cloud is not clear, but

probably to both. Crater *B* is brilliant with snow as long as the Sun reaches its interior.

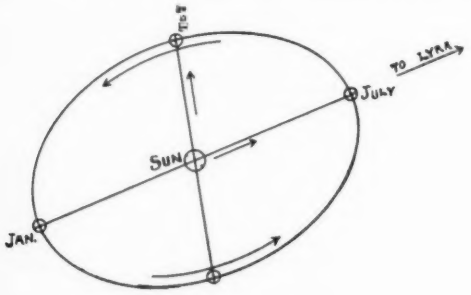
Observations of Plinius give the same results except that the rotation is in the opposite direction, Plinius being located in latitude 15° north. The markings on the wall are not quite as sharply defined as in the case of Theophilus, but its floor markings are much brighter and more distinct, and are subject to very interesting changes of shape as the day progresses, changes which are quite visible even under comparatively unfavorable atmospheric conditions and with a small telescope.

Mandeville, Jamaica, B. W. I.
January 30, 1917.

QUESTIONS SUGGESTED BY THE SUN'S MOTION.

REV. W. E. GLANVILLE, PH. D.

In the present state of astronomical knowledge the Sun's motion should constantly be borne in mind. Lalande's surmise, made in 1776, that as the Sun has a motion of rotation it may also have a motion of transference has been amply confirmed. The fact of the Sun's motion in space has been determined and the direction and velocity of that motion have been ascertained. We are situated not only on a moving observatory (the Earth) but our whole solar system is moving towards Lyra and according to recent estimates our whole sidereal universe, of which our solar system is but a very ordinary member, is in motion in the general direction indicated by β Capricorni.



It is noteworthy that while Lyra and Capricornus are by no means in the same latitude they are both in the same general direction of the heavens.

1. Recurring to the Sun's motion, it by no means follows that the present direction of that motion towards Lyra will continue constant i. e., that the Sun's motion is absolutely rectilinear. The presumption is that the Sun's motion is elliptical and that the time elapsed since the sun's motion was determined has not been sufficient to detect an elliptical orbit. If it be demonstrated that the Sun is traveling in an orbit rendered necessary by the central gravitational force of our sidereal universe it follows that the plane of the ecliptic as related to outlying stars will in course of time change and that the zodiacal constellations themselves cannot be regarded as unalterably fixed with respect to the ecliptic. If such a secular change is taking place as the result of the Sun's motion in an enormous orbit, re-examination of many astronomical constants will be necessary from time to time.

2. Again: The principle that a system of bodies, such as the solar system, contains within itself satisfactory mathematical explanation of perturbations due to the interaction of disturbing forces, is admitted. Still, the question may be raised whether a system of planetary bodies revolving round a *fixed* center is identical in all respects with another system of similar planetary bodies revolving about a *moving* center. Consider the case of the retrogression of planetary nodes, and, in the case of the earth, the analogous phenomenon known as the precession of the equinoxes; also the progression of the apsides; would not the fact of the Sun's motion, controlled by a central gravitative force, demand also a set of nodal retrogressions, not indeed on the ecliptic plane but on the solar motion plane?

3. Does not the Sun's motion account for the fact that the earth requires a slightly longer line to cover the part of its orbit at present included between the summer and winter solstices than it requires to travel the remaining part of its orbit between the winter and the summer solstice? In the former case while partaking of the Sun's motion towards Lyra it is also traveling contrary to that motion in its orbit while in the latter case it is moving in its orbit, so to speak, with the Sun. An inspection of the Moon's motion around the moving earth indicates that it requires longer to cover that part of its orbit in which it is traveling, as it were, contrary to the Earth's motion.

4. From the middle of August to the middle of September excessive temperatures are usually registered all over the world. During that period the earth is curving in, in its orbit, towards the Sun which we may say is advancing towards the earth. Would not this condition account for the excessive heat or, at least, enter as a factor in the problem? Driving along the road towards the Sun on a summer day one notices that a slight elevation of the road produces a very sensible increase of heat whereas on descending the other side of the elevation

a very sensible decrease of heat intensity is noticed.

5. Specialists in meteoric astronomy assert that more meteors, in the proportion of 3 to 1, are encountered between aphelion and perihelion than between perihelion and aphelion. May not this condition be accounted for by the fact of the earth moving in its orbit, at that period, contrary to the Sun's motion, with the result that strains are set up in the meteoric matter in the earth's neighborhood and unusual precipitations of meteors occur. As might be expected such precipitations would be especially notable at the octants in that section of the orbit passed in August and November.

Notwithstanding the fact well known today that the Sun together with the solar system is moving at the rate of 20 km per second towards Lyra, we are too often unmindful of it and think of the Sun as fixed. It is well therefore for us to try to habituate ourselves to think of the Sun in motion.

St. Peter's Rectory,
Solomons, Md., 1916, August 12.

THE TULSE HILL OBSERVATORY DIARIES.

SARAH FRANCES WHITING.

Our great research observatories of today might fairly be called astronomical factories since they turn out results by the wholesale. Stars are classified, as to their spectra by the hundred thousand, as to their radial velocity by the hundred. Well nigh a score of new stars have been discovered by their spectra, the nebulae have been ranked into great classes and their motions determined, while photography has been reduced to an exact science in spite of the fact that the process involves so many variables.

It is well for this later generation of astronomers to pause to contemplate the toils of the pioneers. When the road is made, progress is comparatively easy; it is a different matter to break virgin soil.

Six Tulse Hill Observatory Diaries were sent to Wellesley College with the many rare gifts bequeathed by Lady Huggins. In these books are records of the persevering self-sacrificing work of William Huggins, the pioneer in astrophysics, and his gifted enthusiastic wife and colaborer.

The diaries go even back of the published "Scientific Papers" in giving the record of the "development of astronomical work in an entirely new direction, through the then novel application of the spectroscope to the heavenly bodies other than the sun."

Three of the books give a record of work in the observatory from evening to evening through a period of more than forty years; the others, of work in the laboratory necessary to interpret the evening work, or in the study designing apparatus.

Everything is simply told, with exceptional exclamations of disappointment at the weather or at failure of results, or of exultation at some marked success.

One thing greatly impresses the reader:—amazement at the achievements of English Astronomers in a climate which veils the heavens much of the time. Again and again, following the date, is the statement:—"There was promise of a clear evening, we opened the observatory and prepared for observation, but it proved hopeless." Some problem of intense interest in reference to nova, comet, or nebula might be near solution when a long series of cloudy nights allows the object to get too low for further scrutiny.

I once expressed to Lady Huggins my surprise at her absence from a notable scientific gathering in London, when she replied: "We seldom go anywhere; astronomy is a heart breaking science in England. We mostly stay at home to watch for rifts in the clouds."

If they went, a record like this follows:

"June 24, '81 Hurried home from the Garden Party at Kew, had a hasty tea, out of Sunday best prestissimo, and went at once with my husband to the observatory. Exposed a plate an hour and a half to the comet, developed at once, felt intensely excited. Comet spectrum good. We measured in turn, each checking the other again and again, comparing with the cyanogen flame spectrum."

The first Observatory book was started just sixty years ago. Its beginning reveals that poetic sentiment accompanying scientific work which was to be frequently noted in the *pioneer* workers in every line of science, and was a marked characteristic of this astronomer.

On the first two pages are carefully penned appropriate mottoes from the literatures of several languages. The first is in English: "Ye are a beauty and a mystery." I have not in all cases found the source of the quotations but a free translation follows.

From Genesis, written in Hebrew:— "Look now towards the heavens and number the stars if ye are able."

From the German:—"Star jewels tinted in blue and green, in yellow and vermilion, in the vivid red of porphyry! What marvelous variety of light must they impart to the planets which circle around them."

From the Italian:—"Stars always shine everywhere, giving their light to all, but to those who keep vigils with them they impart their secrets."

From the Greek in Greek letters, the text from St. Paul:—"One star differeth from another in glory."

In Latin the motto of the Royal Astronomical Society:—"Quid-quid nitet notandum." (Whatever shines is to be noted.)

The dedication is in Latin:

"Phenomena which William Huggins observes with his own telescope. This glass for exploring the sky was designed and made by him in 1856."

The equipment of the observatory is then listed and described, and record of observations begins in April, 1856. Huggins first looked at the planets and the usual show objects, and observed occultations and eclipses as they occurred.

He evidently was received into the brotherhood of astronomers, for we find in the book a list of visitors which includes Lord Rosse, his son Lord Oxmantown, Adams, Carrington, Webb, Proctor, Gill, Struve, scores of the most distinguished names. Later, American names begin to appear:—Alvan Clark, Cleveland Abbe, Winlock; but in 1871 a separate visitors' book was evidently started.

The observations at Tulse Hill Observatory naturally group themselves in periods. From 1856 to 1863 they were miscellaneous. About that time, as Huggins relates, his attention was arrested by the work of Kirchhoff in analysing sunlight, and the books show that he immediately seized the idea of extending this analysis to the stars.

During the next period 1863 to 1876, we find record of most exhausting and, as he after remarks, eye-fatiguing work mapping the spectra of fifty stars, and confronting these spectra with those of terrestrial elements.

In 1864 he records his observations of the green lines in the nebulae, and scores of nights were spent trying to match these lines with magnesium, lead, iron, what-not. Many ingenious devices were used before photography came in to carry the comparison from sunlight to every observation. He states:—"We find ourselves in the presence of objects possessing a distinct and peculiar constitution." In 1863 he attempted a wet-plate photograph of the spectrum of Capella and Sirius but found only "great extension in the blue—no lines." In 1864 he records his endeavor by eye-comparisons to carry the Doppler principle to the stars, but he found "eye comparisons too difficult for any exact results."

One day just after the receipt of the books at Wellesley we were making a more detailed study of what is known of new stars. The teacher exclaimed: "Let us look at the Huggins books, and see if we can find record of the first discovery of the nature of this phenomenon." So we found it and read:—

"1866, May 16. Received at 5 o'clock a letter from John Birmingham announcing a new star in Corona, also a letter at 7 o'clock from Baxendall.

"Evening, examined the spectrum with Dr. Miller. The spectrum combined both absorption and bright lines.

"A line which is certainly in the position of the F line is very bright and two beyond.

"May 17. Prepared battery and coil, line in blue *certainly* coincides with Hydrogen. Could not on account of its faintness get red line clear, but fully believe it agrees with C."

Many records of prolonged and careful comparisons follow.

"August 16. Saw new star and suspect presence of lines in green.

Finally September 16, "Observed T Coronae for two hours with different forms of apparatus. I could not be certain, but at times it appeared as if several bright lines crossed the green."

In 1879 is the record of the first observation of the form of a solar prominence with open slit.

In 1874 occurred the marriage of Dr. Huggins with Margaret Lindsay Murray of Dublin, who had from childhood been unwittingly preparing herself for an astronomer's colaborer. After the marriage most of the records are in Mrs. Huggins' clear handwriting, and drawings are of her good workmanship.

From '76 on there follow records of a long series of experiments in photographing spectra, culminating in the splendid plates of the Atlas of Representative Stellar Spectra. Lady Huggins is the one who guided the telescope for the long exposures. There were no precedents to follow. Times of exposure, types of sensitive plates, developers, forms of spectrographs, finally a reflecting telescope, all had to be tried out, and lines now recognized at a glance must be identified.

In 1876 Vega "showed lines" on a plate and it is recorded that they "believe there is high probability that the new lines are due to hydrogen."

In 1876 the diary states, "We note the different appearance of the K line in different stars; would this aid in arranging spectra in a continuous series." They record their great interest in the work of Draper in 1877 and discuss his results compared with theirs.

In 1888 they develop a plate of the Orion nebula which Professor Liveing examined and records in their book in his own hand his interest in the appearance of the green lines on a plate.

Attempts at photographing the Andromeda Nebula were made in 1887.

"December 5. Plate on Andromeda Nebula one and one half hours. Sky not clear much of the time. I knew that time could give no image, and I persuaded "W" not to develop, but to gently close the shutter and leave the plate in the camera to go on with the next fine night."

This plate was exposed at intervals and not developed until sometime in January. Was not this an early example of exposure from night to night? They evidently expected to get the green lines of the Orion nebula. They record:

"Comparison spectrum good. No lines; disappointing!"

The record adds:

"We work at the Andromeda Nebula with more interest as Mr. Roberts of

Liverpool has just sent us a photograph which shows clearly a system in process of making. Mr. Roberts' plate is certainly the most interesting photograph of a celestial object ever taken. This photograph gives the body; if we can get the spectrum we shall have the soul.

"In 1891.—Tried to see if there is any warrant in the spectrum for the contrasting color in double stars."

Later records of work on Alpha Hercules state:

"I succeeded in keeping B out of the slit and got an excellent photo of A.

Finally after several disappointments the record is: Examination of plates shows faint spectrum of B. The stars are certainly in different stages of development."

Notes of their work on Nova Aurigae in 1892 are interesting.

"Just after midnight came a telegram from Dr. Copeland announcing a nova two degrees south of Chi Aurigae. At that hour object too low for us to do any useful work. Both of us have influenza but after much persuading and entreating I prevailed upon my husband to let me work in the evening if it was clear.

"The nova a splendid object, spectrum crowded with bright lines. Proceeded to make comparisons with hydrogen, sodium, manganese, lead, nitrogen.

"February 3 cloudy! February 4. Began at six. Observed in turn. W's observations and mine agreed. Clouds came up but we worked in the brief intervals between. I squatted on a rug and kept my eye on the spectroscope until 8:45. Saw a few things well. W. threw in the comparison spectra.

"February 6. Watched the night anxiously although we were very weary,—hopeless till 9:30 then clearing and worked till 11.45—making comparisons by flashes between clouds. Worked as carefully as I could, but not the same confidence as on a clear night.

"February 20. Still cloudy, but went to the observatory. Could only make sure that the star was still there, and this was consoling. Although looking forward to the death of this brilliant spectrum, we do not want it to die yet, we are consumed with anxiety to repeat our comparisons for line of sight motion."

A later night records:

"Line C superbly bright. We put on the large spectroscope with the 15-inch but were utterly tormented by the dew forming on everything. Finally had to give up although the night was fine.

"Then decided to put on a plate and take a photograph of the ultra-violet, with the 18″ reflector. Began at 8:45 and I kept the star on the plate till 10:30. Watched the star without a moment's intermission using first one eye then the other. Developed the plate, a beautiful photograph running along the ultra-violet as far as the photograph of Sirius."

There are records of fifteen nights work on Nova Aurigae.

Constantly new methods were tried. Sir William's mind was fertile in devices, they were continually setting up new instruments and gaining in skill. "W" and "Madge" worked constantly together checking each other's observations.

These observers finally reached a time of constant successes. They record their examination of photographs received from Harvard and Potsdam, and their satisfaction at the performance of their newer instruments.

A discussion arose as to the compound nature of the line D_3 of Helium. Huggins could not see it, but finally, using the fourth order of a Rowland grating received from Brashear, he picked up the fainter component. Lady Huggins was in town and she states, "William was so delighted he thought of telegraphing to me. I wish he had."

There are little human touches in the records interesting to note:—

"While William was taking his turn at observing, and there was nothing to do, and he was silent, I looked at various things with the Ross opera glass."

"We worked on through the intense heat and were much troubled by films pealing off."

"It was Sunday night but as it was fine we felt it a duty to continue our research."

"It was bitterly cold and not very clear, but we took a photograph of the spectrum of one of the three stars above the trapezium in Orion."

The Scientific Papers and the Atlas of Representative Stellar Spectra detail the results of the work recorded from day to day in these diaries;—a remarkable output for two astronomers entirely unaided except by the instrument makers,—and this work laid the foundations for the amazing revelations of astrophysics.

THE AMERICAN METEOR SOCIETY IN 1916.

CHARLES P. OLIVIER.

The following brief report of the work done during 1916 is made for the information of members and others interested in the progress of meteoric astronomy.

This Society was organized late in 1911 and its first publication, covering 1911-1913 inclusive, contained results from 2817 observations. The work of 1914 and 1915, which consisted of 597 and 5004 observations respectively, has been completely reduced and the manuscript prepared for publication. This has been accepted by the National Academy of Sciences and it is hoped that it will shortly be published as a Memoir of that Society. Reprints will be distributed to all members of the American Meteor Society, several copies to each of those who have contributed to the work.

The immense gain of 1915 was even surpassed in 1916, and during the year just ended no less than 10184 observations have been reported to date to the central office at this observatory. As 44 observers situated in 14 states and 4 Canadian provinces took part, it will be seen that 1916 was by far the most successful year, so successful indeed that it will be difficult to hold to this high average in coming years

unless we can increase our present membership. It should be added that probably a few other reports are now enroute, but will be received too late to be included in this preliminary report.

The following table contains the name and station occupied by each member, and the total number of nights on which regular observations were made and the number of meteors recorded.

Aldrich, Richard	Wichita, Kan.	1	17
Aude, Mrs. Beatrice	Watertown, N. Y.	2	38
Bancroft, H. C.	West Collingwood, N. J.	*	8
Bedford, J. L.	Watertown, N. Y.	4	105
Bessey, Mrs. Grace	Pensacola, Fla. Mobile, Ala.	9	378
Bostick, Dr. J. B., U.S.N.	Dallas, Tex.	4	15
Briggs, G. B.	Sebrell, Va.	3	50
Brooks, Donald	Washington, D. C.	46	1519
Burge, Olaf	Wichita, Kan.	9	249
Carr, Frank J.	Swanton, Vt.	3	51
Carreau, Napoleon	Wichita, Kan.	3	36
Chiles, E. G.	Cleburne, Tex.	5	26
Crain, J. W.	Danton, Tex.	5	41
Dawson, B. H.	At Sea	1	14
Doubt, John	Savage, Mont.	m	2
Doolittle, Alfred	Washington, D. C.	1	5
Dunlop, A. R.	Kelwood, Man.	1	5
Eaton, Howard	Madison, Wis.	m	3
Gannon, H.	New York, N. Y.	2	14
Fankhauser, A. G.	Sioux City, Iowa.	4	60
Grace, Gerald	Wichita, Kan.	2	8
Irwin, S. D.	Whitestone, L. I., N. Y.	2	9
Koep, John	Chippewa Falls, Wis.	84	2654
Kronenberger, G. F.	New York, N. Y.	9	24
Lambert, Raymond	Newark, N. J.	42	1006
La Paz, Lincoln	Wichita, Kan.	15	843
Laughten, Harold	Wichita, Kan.	1	6
Lifferton, Miss Doris	Lachine, Quebec.	10	37
Ludeman, Clarence	Wichita, Kan.	4	341
Martin, H. H.	Fort Worth, Texas.	15	145
McPherson, W. L.	Wichita, Kan.	3	129
Olivier, C. P.	Univ. of Virginia	3	101
Observers at McCormick Obs	Univ. of Virginia	*	22
Partillo, Col. J. M. T., U.S.A.	Inglewood, Calif.	9	50
Parsons, Newman	Frederick, Md.	2	6
Post, Emil	New York, N. Y.	10	59
Rasmussen, M.	Amsterdam, N. Y.	3	113
Simpson, T. McN.	Richmond, Va.	1	5
Smith, W. K.	At Sea	1	29
Taulbut, A. S.	Mission City, B. C.	1	6
Trudelle, Philip	Chippewa Falls, Wis.	81	1828
Werhun, W. W.	Hampton Station, Sask.	3	61
Wohlwend, Henry	Knoxville, Tenn.	2	* 4
Young, Dayton	Wichita, Kan.	2	36
Misc.			26
Total for 1916:		387	10184

* Telescopic meteors. m Miscellaneous Meteors.

A glance at the table will show there are three places in which exceptional interest was taken. One is Wichita, Kansas, where Mr. Lincoln LaPaz, not content with a large personal contribution to our

total, has succeeded in interesting a large number of others, several of whom also sent in large contributions. But the very fact that so many persons in one place have taken enough interest to work on meteors at all promises very well for the future in that locality.

The second place deserving special mention is Chippewa Falls, Wis. Our two observers there, Mr. John Koep and Mr. Philip Trudelle, sent in the largest single contributions received. Indeed few observers in the whole history of meteoric astronomy, either here or abroad, have ever observed so many meteors during one year. They have established a most excellent record. By their observations the author was able last summer to discover and prove the connection between the 1916 May-June Meteors and Pons-Winnecke's Comet. This proof has been the subject of several papers already published both in this country and abroad. Nothing could show better the real importance of the work done by our members, adding as it did the sixth certain proof of such a connection in the whole history of astronomy.

The third place to mention is Fort Worth, Texas. Here Mr. H. H. Martin of the U. S. Weather Bureau has been working for the past year with other local observers to obtain observations of meteors simultaneously, from which their real heights may be computed. He has most kindly sent in copies of all his results for the summer and fall of 1916, which consist of 27 cases he considered proper for computation, besides other lists of meteors. A few of these have already been computed here and work on others will be undertaken shortly. These results cannot fail to be of much interest.

A word should be added here about some of our observers who live in large cities or cloudy belts. These frequently have observed through several hours of a night and been able to record very few meteors compared to those of us who are favored by clearer skies. Their enthusiasm is all the more commendable in observing under difficult conditions and with the certainty of a smaller reward for their work.

Reductions of the immense number of observations received in 1916 have been begun, but so far the author has had to work without assistance and consequently only a part have been completed. To date over 80 parabolic and 9 elliptical orbits for meteor streams have been finished and these numbers will no doubt be doubled before all the data have been worked up.

Looking forward to 1917, the following remarks should be made. Members are requested to send in reports as promptly as possible at the beginning of each month. Requisitions for maps and blanks should accompany the reports. As everything depends upon the accuracy of the plotted paths, each one is urged to pay especial attention to the meteor's path and draw it at once with all possible accuracy, leaving

the filling in of the blanks until this has been done. No meteor should ever be recorded unless seen with absolute certainty. If only suspected, never record it. Several hours of observing on one night is far better than one hour on several nights. Observations of less than one hour's duration are almost useless. Attention is called to the fact that since each night's work is complete in itself, we are glad to have observers who can work, for example, only one night per month. Their work is valuable, and it would be most unfortunate if those sending in few observations should, on comparing their totals with those of others, conclude that their work was of little value. Nothing could be more disastrous for the future of our Society. As has been stated before, maps and blanks are mailed without charge to every working member. Finally each member is urged to use his influence toward gaining the assistance of others in our work. Some of our best observers may at any time have to resign, and we need others to take their places. In any case we desire to increase our membership and the number of our observations. If each present member would interest one new person, the result would be most gratifying.

Grateful acknowledgement is again due to the National Academy of Sciences for a further grant of $300 from the J. Lawrence Smith Fund, which has permitted the extension of the work in 1916. Also to officials of the United States Weather Bureau for kindly communicating valuable data received from their observers. Further the American Astronomical Society, recognizing the value of the American Meteor Society's work, appointed the author secretary of its Meteor Committee. This was done to show its appreciation and interest in our results and, by giving its official sanction, it was hoped that there would be a greater revival of interest in meteoric astronomy among professionals as well as among amateurs.

Leander McCormick Observatory,
University of Virginia.
January 22, 1917.

THE IMPACT ORIGIN OF THE MOON'S CRATERS.

DONALD PUTNAM BEARD.

Quite recently there has been a revival of the old discussion concerning the origin of the enigmatic features which our satellite, the moon, betrays; features peculiar to lunar physiography alone, and which find no mundane counterpart. Until within a score or more of years the time-honoured volcanic doctrine of causation of those great circular mountain ranges termed "craters" has held well-nigh undisputed sway.

This misapprehension as to the true origin of the lunar craters is a traditional opinion handed down to us from the days of Galileo's "optik tube", and is still held by many leading investigators, notably Puiseux, of the Paris Observatory, Professor W. H. Pickering, H. Ebert of Munich, E. W. Maunder of England and other noted investigators. The word "crater", primarily derived from the Greek name of a kind of bowl or cup, has unfortunately come to possess an implication of specifically volcanic origin when used in a geologic—or lunar—sense.

Perhaps the oldest theory of the volcanic origin of the lunar craters was that advanced by Robert Hooke in his "Micrographia", circa 1667 *. In this work he suggested that they are caused by the bursting of Cyclopean bubbles in the once viscid surface of the moon, which later solidified into the crater rings. However, this theory fails to account for the vast proportions, the central peak, the inner plain and other fundamental features inherent in lunar craters, and therefore does not commend itself to serious consideration.

A more rational hypothesis is the tidal-stress theory, which had its inception simultaneously in England, France and Germany † and is based on the tidal influence of the earth upon the moon. If, as Professor Sir G. H. Darwin has mathematically postulated ‡, the moon was sundered from the semi-solid primaeval earth rotating on its axis once in about four hours, the former must have revolved in close proximity to the latter for several millions of years. Tides of unimaginable magnitude were raised by each in the other, and these enormous

* A. St. Clair Humphreys: Journ. British Astronomical Association, December, 1891, p. 132.

† J. B. Hannay: Nature, vol. 47, p. 7, (1892). Also, Faye: Rev. Scientifique, 27, p. 130, (1881). Also, H. Ebert: Anneln Physik und Chemie, vol. 41, p. 351, (1890).

‡ In art., "Tide", Encyclop. Brittan., V. xxvi, pp. 960-61. 11 ed.

tidal stresses are supposed to have ruptured the viscid lunar crust into fissures, from which exuded the inner liquid lava. With the passage of the tidal wave, the lava retreated within, but not before congelation, arresting the flood at its edges, marked its boundaries by a solid, circular range.

A few fatal objections, however, may be advanced which this theory does not satisfactorily meet. The alternate extrusion and retraction of lava would have divided the entire surface into a close plexus of cracks, such as are seen in drying mud or concrete. This result of tidal stresses is not observed on our satellite, save in a few instances, and these are referable to another origin. Again, according to this theory, the larger craters must have taken precedence over the smaller in the order of formation, and at an epoch when the viscid surface would not possess sufficient rigidity to sustain the massive crater formed. Furthermore, as will be shown later, the moon could never have undergone fusion in the gathering together of her mass, and consequently that *primum mobile* of volcanic forces, a molten and viscid interior, was never achieved in the early dawn of our satellite's evolution.

The idea that the moon's craters were formed by the impact of gigantic meteoric bodies apparently originated with Gruithuisen, a German selenographer, some fifty years ago. The late R. A. Proctor mentioned the meteor impact theory at some length in his book, "The Moon,"* and later advocated this theory†. More recently the late Simon Newcomb refers to it as an astronomical curiosity in his textbook, "Newcomb's Astronomy."‡

But the analytic development of Gruithuisen's original idea into a coherent working theory of the origin of the moon's features is due to a geologist, Professor Grove K. Gilbert, of the United States Geological Survey. In his classical address as Retiring President of the Philosophical Society of Washington, 10th December, 1892, Gilbert gave exhaustive consideration to the origin of the rugged and precipitous craters, the dark plains or "maria", the bright streaks radiating from Tycho, Copernicus and other craters, together with several anomalous features which lend such striking emphasis to a phase or full view of our satellite. He concluded that the impact theory best explained the phenomena included within its purview.¶

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* "The Moon": R. A. Proctor, London, 1873, p. 345.

† Belgravia, vol. 36, p. 153. (1878).

‡ "Newcomb's Astronomy": Simon Newcomb, New York, 1892, p. 320.

¶ "The Moon's Face": Sci. Amer. Suppl., vol's. 36-37: pp. 14, 994-99; pp. 15,003-06; pp. 15,016-18. (Dec. 23-30, 1893 and Jan. 6, 1894.)

PLATE VI.

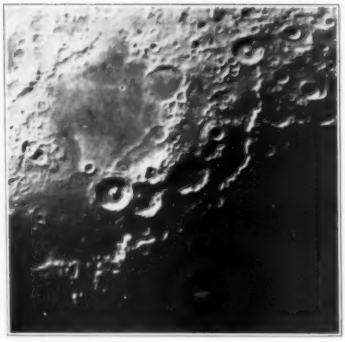

FIGURE 2. The lunar crater Theophilus, (0.6; 0.8); from a Lick negative. The position of a crater in these photographs is indicated by two numbers in brackets. The first number gives the distance of an object in inches and tenths from the left-hand edge; and the second its distance from the bottom edge, as in W. H. Pickering's atlas of the moon. This is a typical lunar impact crater, from 17,000 to 19,000 feet deep, and 64 miles in diameter.

FIGURE 4. Portion of the "great South-west" region west of Tycho, from a Lick negative. Maurolycus is shown above the center (0.8; 0.9). The crater Maurolycus is a good illustration of the overlapping and partial obliteration of a smaller crater, formed earlier, by the impact of a larger moonlet.

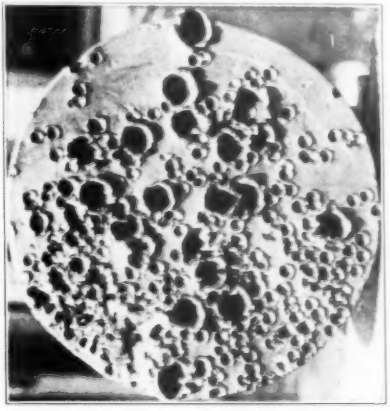

FIGURE 3. Photo of a lead target riddled with .22 caliber bullets and No. 8 shot. This experiment, made by the writer to show the effects of impact on a surface of similar material, strikingly illustrates the origin of the moon's craters by impact. Since these laboratory "craters" are on a much smaller scale than their lunar counterparts, it is impossible to reproduce all the details of inner terracing, central cone, and complex wreath structure seen in the latter. However, the first and last features mentioned are closely approached in the experiment.

Since they are the dominant feature of a first-quarter view of the moon, primary consideration will be accorded the craters.

The Craters. When one surveys the moon about first quarter by aid of a good glass, the sun is then seen rising upon the rough and jagged craters in the zone of sunlight near and along the terminator, their loftiness magnified by the spire-like black shadows they throw across the plains. Seen thus, these peculiar objects reveal themselves as deep circumvallations with steep and disordered terraces akin to "landslip" terraces on the earth, varying in size from such as Clavius, Schickard and Petavius (respectively 143, 134 and 93 miles in diameter), down to the cup-shaped crater pits an eighth of a mile across, appearing as minute "pin-holes" in a large telescope. The selenographer Neison classified them as crater pits, craterlets, craters proper, crater plains, ring plains, mountain rings and walled plains, recognizing gradation between the craters and maria. Accordingly, they are all to be regarded as intergradations or phases of a single species; all owe their origin to a common cause.

The prevailing theory is to the effect that the lunar crater features described above are volcanic in origin; that the dark circular maria are the sterile beds of vanished seas, and that the "rays" emanating from certain craters are the effects of extrusion of light-coloured lava from the interior of a primaeval moon racked by tidal stress. How far this view finds substantiation from physical and astronomic reasoning, or in what measure it avoids the difficulties which beset it, may presently become clear.

Distribution. Doctor T. J. J. See of the Mare Island, California, Naval Observatory has recently completed certain revolutionary investigations in terrestrial physics which conclusively prove that the pressure of the oceans on their basins forces sea-water through crevices in their floors, and this water, coming into contact with superheated lava deposits located under the edge of the coastal crust, causes vast portions of the latter to subside. This unequal subsidence forces the underlying lava up under the continental borders, and the long-continued action of these disruptive processes rear the great terrestrial mountain chains and gives rise to volcanoes and earthquakes*. The Bogoslav Islands, which rose from the waters of the north Pacific—in the Aleutian Group—in September, 1907, is a striking illustration of these mighty world-modeling forces.

Applying Doctor See's theory of volcanic causation to the distribution of craters on the moon, we are confronted with the fact that the lunar "volcanoes" are most widespread where we should least anticipate their

* "Researches on the Evolution of the Stellar Systems", vol. ii, art. 169, pp. 352-54.

presence; i. e., in the "great south-west" about the crater Tycho and in the smooth dark "maria", while in the proximity of the "sea-shores" they are relatively scarce. Such failure of expression on the ancient "sea-borders" is due to lack of aqueous motive power, and is irreconcilable with the supposition that these reputed ancient seas once held water.

The late Professor N. S. Shaler of Harvard revived Robert Hooke's old theory—previously adverted to—and asserted that the lunar craters are the solidified remnants of bubbles which formed in a molten surface ages ago and subsequently burst.* Professor Shaler postulated the impact of meteors of planetoidal proportions for the genesis of the maria, but failed to recognize the community of origin with the craters evinced by the latter.

In view of the absence of any evidence of oceans or aqueous action in producing volcanic formations on the moon, are we not warranted in seeking further for a *vera causa* of the phenomena disclosed by the five-ninths of that orb which we are privileged to behold?

Form. The predominant type of volcano on the earth is perhaps best represented by Vesuvius or Stromboli, the former shown in profile in Figure 1. The Vesuvian crater is usually a lofty mountain, sloping gradually from its apex to a broad base, while the inner walls incline more abruptly to the crater floor within. The solid material extravasated from the vent of the volcano gradually builds up a cone

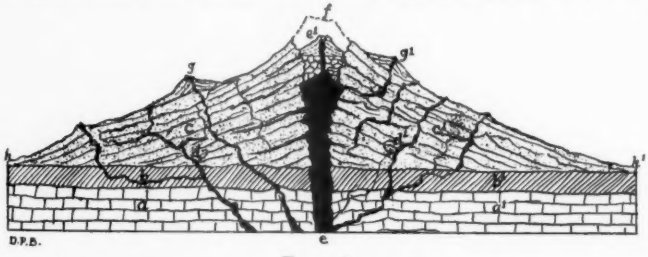

FIGURE 1.

Profile or horizontal section taken through an ideal volcanic vent of the Vesuvian type on the earth. The complete dissimilarity demonstrates emphatically that the terrestial volcanoes and lunar "craters" have not known a cognate origin, but are caused by widely different forces.

several miles in height. The craters of Vesuvian volcanoes are small in comparison with the cone formed by the ejected lava, while the central hill, if present, is punctured at its summit by a vent. These volcanoes are violent and explosive during eruption, since their lava

* Cf. Smithsonian Contributions, 1903, part ii, pp. 103-13.

contains so large a proportion of water that its conversion into steam rends the ejecta into fragments and fine dust, the latter floating for many months in the upper reaches of the atmosphere, producing very satisfactory and brilliant sunset effects for the aesthetically inclined.

Figure 2 is an enlargement of the lunar crater Theophilus made from a Lick Observatory negative; this may profitably be compared with the preceding cut of Vesuvius. The inner height of the cliffs of the lunar crater is over double and even treble that of the outer, while the basin of the crater is deeply sunk beneath the level of the outer plain. The diameter of Theophilus is about 64 miles, with a maximum depth from inner plain to the summit of about 18,000 feet.

A terrestrial contrast to this is afforded by the obelisk-like spine of viscid lava which rose from the caldera of Mont Pelé in May, 1903, to a height of 1,200 feet above the rim of the crater.

Finally the rim of a Vesuvian crater is not developed into a complex wreathed and terraced structure as typified by Theophilus or Copernicus; it is devoid of the successive terraces on its inner slope, while the smooth inner plain of the lunar crater fails of any recognizable likeness to the rough disorder of the lava beds of Vesuvius and Krakatoa. Indeed, Professor Pickering states that "the features that are most prominent in our ordinary terrestrial volcanic regions are never seen upon the moon."*

The Hawaiian type of volcanoes, represented by Kilauea and Mauna Loa, are characterized by a low, nearly circular rampart containing a level expanse of solidified lava which slightly resembles the inner floors of Plato and Eratosthenes on the moon. The eruptions of these volcanoes do not liberate vast quantities of steam-gorged lava during that process; hence, eruption is only a quiet welling up and overflowing of the caldera. They slightly resemble lunar craters in that they exhibit inner plains, and a certain terracing of their inner walls is noticeable. Yet, the fact that the rims of the former are devoid of complex wreaths and "landslip" terraces and slopes and that none, save one or two, are exceptions to the universal law of elevated planes, and that the central cone is absent, constitute the differences which far outweigh any fancied resemblances between the contrasted types.

Origin. If we conceive the moon as an edifice which had its foundation in a ring or shoal of meteors encompassing the primaeval earth, and similar to the giant planet Saturn (the meteoric constitution of whose rings was spectroscopically demonstrated by Keeler in 1895), and if we imagine this shoal gravitating together and building up our

* "The Moon": W. H. Pickering; New York, 1903. p. 24.

satellite by accretion, no violence is done the essential principles of Laplace's immortal Nebular Hypothesis. Meteors replace molecules, that is all, as long ago pointed out by the late C. A. Young.* The mechanical behaviour of a meteor swarm containing individual masses and endowed with the ordinary velocities of meteors would be precisely similar to a nebulous mass of continuous gas.

The mathematical analysis of the mechanical conception of a Saturnian ring is not in place in a discussion of this nature, but by imparting to the postulated meteors in the swarm orbits not widely variant from that of the moon's, and in a similar direction, their initial velocities at impact were small as compared with those created by the moon alone. Since the course of these moonlets were parts of curved orbits with the moon at their focus, they cannot justly be considered as straight lines. By restricting these meteors to a thin plane ring, and assuming a fairly equable distribution through this plane, the distribution of impact angles deduced by Gilbert yields a curve in which 58 per cent deviate from the vertical less than 20°; 70 per cent less than 30°, while 80 per cent fall within 40° from the true vertical. To the vertical infalls consequent upon this condition is due the prevalent circularity of the craters and obviates a resort to R. A. Proctor's improbable suggestion of an elastic return to circularity.†

Laboratory experiments with a lead disk 5.5 inches in diameter and about 0.5 inches thick as a target, into which .22 caliber bullets of the same material were fired, demonstrate experimentally the effects produced by the impacting moonlets upon the moon's surface. Interesting replicas of the moon's crater forms were thus obtained by the writer, and are well shown in Figure 3. Compare with the great pitted region of the moon shown in Figure 4.

Overlap. An instance in which a larger crater overlaps and partially obliterates an earlier and smaller formation is shown in Figure 4, which is an enlargement of Maurolycus, in the roughest portion of the moon. The observed fact that there are comparatively few of these examples is eagerly taken by the volcanic advocates as proof positive that the moon's craters are defunct volcanic formations. But the very paucity of instances, far from proving the truth of the volcanist's contention, is mutely eloquent in our defense, since the probabilities would be overwhelmingly against the survival of this species of "overlap" crater. Yet this superposition of larger over smaller craters is exemplified by Longomontanus, Maurolycus, Hainzel, Schiller and others.

Sculpture. The peculiar plateau of Wargentin and Phoclydes b,

* "General Astronomy": 1889. art. 526, p. 296. (Boston.)

† "The Moon": R. A. Proctor, p. 346.

PLATE VII.

FIGURE 5. Enlargement on bromide paper of the plateau Wargentin (1.0; 0.8); from Nasmyth and Carpenter's "The Moon." To the south (or above) of Wargentin appears a similar elevated plateau, or crater filled almost to the level of its rim with molten lava splashed into it from the moonlet impact which created the Mare Imbrium.

FIGURE 6. The Rheita Valley (0.9; 1.1); from a Lick negative. Note the peculiar south-easterly off-shoot of this groove, due perhaps to deflection or diminished momentum of the graving matrix of rock borne across this region of the moon from the Mare Imbrium. A long, narrow valley is seen to extend from the western edge of Piccolomini (0.9; 0.6) southward and almost parallel to the Rheita Valley.

FIGURE 7. Valley of the Alps (0.5; 0.8); from Nasmyth and Carpenter's "The Moon." A good example of grooving by a moonlet striking a glancing blow.

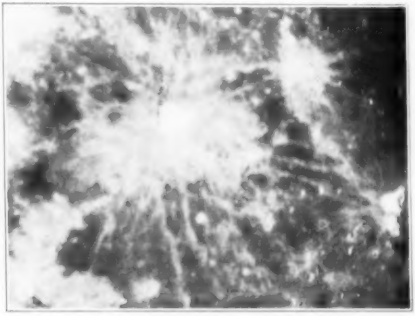

FIGURE 8. Copernicus (1.0; 1.1), Kepler (1.8; 1.4) and Aristarchus (2.3; 0.7); from a Goodsell Observatory negative. The systems of bright streaks radiating from the first two craters are due to the collision of moonlets containing considerable quantities of light-coloured minerals. Professor Wood's photographs of the moon in ultra-violet light have revealed a large deposit of sulphur to the east of Aristarchus.

shown in Figure 5, are striking examples—in more than one sense—of some tremendous lava deluge. The first-named object is a smooth, nearly circular *mesa* 54 miles across and filled nearly to the level of the lowest point of its rim with solidified lava. That Wargentin does not reign alone in his unique grandeur is proclaimed by the partial filling of Gassendi, Letronne and Hippalus to the north; craters which experienced a community of origin with Wargentin and the neighbouring depressions.

As the result of moonlet impacts in the adjacent maria and the fall of lithic dust from their conflagrations, Boscovich is scarcely to be recognized as a crater, while Julius Caesar and Le Monnier have nearly lost their characters. To the vapourization of the more massive bodies the many "ghost craters" on the moon owe their partial effacement, typified by Fra Mauro, Fracastorius and Cassini. As Doctor See wrote concerning these dim spectres of the desolate lunar Hades:* "So far as one can see, only two explanations are tenable: 1. The deposit of cosmical dust from the heavens, and from conflagrations arising in the impact of satellites. 2. The partial melting down of the walls by the conflagrations which produced the maria, so that only an outline of the original crater walls can be traced."

The southern boundaries of the great Imbrian lava deluge visioned forth as occurring far down the vista of the ages were determined by Pitatus and Hippalus, while southwestward the onslaught of the impacting planetoid's molten flood attained Posidonius, and eastward it lost itself in the Oceanus Procellarum. By this memorable world-wide cataclysm, which at one stroke wrought the Maria Imbrium, Nubium and Humorum and the encircling ramparts known as the Apennine and Caucasus ranges, "were introduced the features necessary to a broad classification of the lunar surface".

Lunar "Valleys". A veritable "Valley of the Moon" is the Rheita Valley, shown on the photo of the crescent moon, Figure 6. This is a shallow groove of varying width with a shorter off-shoot on the south end. It runs from the eastern edge of the crater Rheita southwestward more than 185 miles to Rheita d; its breadth varies from 11 to 25 miles, with a maximum depth, according to Beer and Madler, of about 11,000 feet. A long, narrow cleft resembling a rill, starts from near Piccolomini and trends southwestward more than 450 miles to near Metius, which temporarily interrupts it; but as shown in Figure 6, it continues its course beyond that crater and to the right of the Rheita Valley.

However, the Alps Valley, Figure 7, a straight defile traversing the

* Scientific Amer. Suppl., vol. 69, p. 204, (March 26, 1910).

lunar Alps range, is the most interesting of them all; betraying an exceptional character which demands for its origin an exceptional explanation. A trough-like flat bottomed groove trending east-north-east by west-south-west clean across the Alps range; it is 83 miles long by from three and one-half to six miles in width, and from its positioning bespeaks kinship to the Imbrian deluge, thus uniting the furrow group of the western district with the eastern sculpture system.

Bright Rays. The system of brilliant rays which radiate from the crater Tycho down the lunar disk, like luminous parallels of longitude, and also the wavy streaks converging upon Copernicus; the lesser systems of Proclus, Kepler and Snellius, are the most enigmatic phenomena of the moon's surface. Those emanating from Tycho extend for vast distances across the lunar disk; in one instance—that of the one crossing the Mare Serenitatis—near 1,800 miles. Straight as the famed canals of the desert planet Mars, they seem not to mind obstructing craters or elevations in their pre-determined path. As a contrast, those radiating from Copernicus are branched and wavy and much shorter than the Tychonic phenomenon. The feathery tentacularity of the Copernican system is well shown in Figure 8.

Most conspicuous at full moon, under the vertical solar illumination, they seem to be superficial colour-streaks only, and one can be seen on the inner floor of Saussure, near Tycho, and may even be traced up its inner cliffs, like a vein of volcanic trap piercing sedimentary rock-strata on our own planet. This is a treacherous analogy, however, as Mr. R. S. Tozer has pointed out.* "The lowest visible stratum on the moon is dark, the configuration of the edges of the light coloured portion showing plainly that the darker portions extend underneath . . . . Whence, then, the light coloured lava?

These brilliant rays cannot be inner material extruded from beneath a crust rent by tidal stresses, since an exact restoration of level which would not cast shadows at sunrise or sunset along hundreds of miles would be practically impossible. But the suggestion advanced by Mr. William Wurdemann of Washington, D. C., seems more plausible; viz.,† that "a meteorite, striking the moon with great force, spattered some whitish material in various directions." Furthermore, Professor Gilbert, in the lecture previously adverted to, made the prophetic suggestion that "perhaps the free iron and nickel of meteorites may stand sponsor for free sulphur or phosphorus in moonlets."

This apparently unwarranted speculation of Gilbert's seems to have

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* "The Mountains of the Moon", Scientific American Suppl. Vol. 59, p. 24,632. (June 17, 1905).

† From a letter to Dr. B. A. Gould on the origin of lunar topography.

been verified by Professor R. S. Wood of Johns Hopkins University.* Twelve photographs taken by Professor Wood in ultra-violet light (λ = 3,000-3,250) revealed the existence of an extensive deposit of sulphur near and east of the famous crater Aristarchus (see Figure 8), which is so refulgent that Sir William Herschel is reputed to have mistaken it for a volcano in eruption, when he observed it telescopically in the dark portion illumined only by the ruddy earthlight. These photographs, taken by means of ordinarily invisible light, throw a flood of light on one of the most obscure problems of our satellite's physical constitution. The moon was photographed with a quartz lens 4.7 inches in diameter, heavily coated with silver nitrate. Letters painted by Professor Wood on a magazine cover with zinc oxide (Chinese white) came out jet black in the photograph.

Summary. The foregoing cursory discussion of the moonlet impact doctrine, adhering to purely physical lines of reasoning, has revealed an hypothesis which logically and comprehensively illuminates the varied and obscure phenomena of our satellite, the moon, and reconciles theory with the details revealed by the telescope. As Professor Gilbert fittingly remarked:† "The impact theory applies a single process to the entire series, correlating size variation with form variation in a rational way. It brings to light the history of a great cataclysm, whose results include the remodeling of vast areas, the flooding of crater cups, the formation of irregular maria and the conversion of mere cracks to rills with flat bottoms . . . In fine, it unites and organizes as a rational and coherent whole the varied strange appearances whose assemblage on our neighbour's face cannot have been fortuitous."

Through the inconceivably gradual process of accretion the substances which were busied to form the moon's mass did not undergo fusion. Consequently, the motive force for the initiation of volcanic processes was never present in our satellite. And even had molten lava underlain the lunar crust, the absence there of seas in the dark maria went bail for the immunity of the moon against the ravages of volcanic fury.

A larger orb, such as the earth and the major planets, passes through epochs in its evolution from a widely diffused gas or a meteor swarm to a cold, inert cinder which smaller orbs, by reason of the paucity of their masses and relatively greater surface, may never know. The nascent moon must have attained and passed her heat-acme when materially less massive than now; yet even so, she was darkly cold from center to circumference. She was destined to remain cold and meteoric from first to last, experiencing none of the varied states

* Sci. Amer. Suppl., vol. 70, p. 125. (August 20, 1910).

† Scientific Amer. Suppl., vol. 37, p. 15,017. (Jan. 6, 1894).

through which Jupiter or Saturn passes. In this connection it is pertinent to consider the late lamented Doctor Percival Lowell's remarks on the possibility of past volcanic action on the moon as follows:* "On the principle that the heat to cause contraction was as the body's mass, this state of things on the surface of our satellite is unaccountable. The moon should have a surface like a frozen sea, and it shows one that surpasses the earth's in shagginess." He then proceeds to evaluate the internal heat (or rather the lack of it) generated by the moon through accretion. This, he shows, could not have exceeded 450° absolute, which reduced to Fahrenheit scale, reads −9° F. "To point out that any volcanic action could be produced by this quantum of heat is superfluous", he adds significantly.

In the Saturnian ring postulated above, the earth was once surrounded by a shoal of discrete meteoric bodies of varied masses, which suffered perturbations destructive to its stability. Doubtless many centers of aggregation formed in the disintegrating pre-lunar ring; since were the moon the only center, the scars produced by the subsequent impacts would all be small. As heretofore stated, this view is not opposed to Laplace's Nebular Hypothesis, since Professor Sir G. H. Darwin demonstrated mathematically that a cloud or ring of meteoric bodies behaves substantially like a gas. Since, according to the kinetic theory of gases a gas is merely a swarm of separate molecules, the distinction is one of mass only, and does not invalidate Laplace's majestic conception of the annulation of a contracting nebulous mass. As Professor Sir G. H. Darwin fittingly remarked:† "I believe that the theory I have just explained (meteoric) as well as the theory to which I am coming (Laplace's) contain essential elements of truth, and that the apparent discordances will someday be reconciled."

Thus meteors, or rather moonlets, act as protagonist to the solution of the lunar enigma; Rosetta stones by which we may comprehensively decipher the age-old lunar hieroglyphic and evoke a clear conception of what went before our tardy advent upon the scene of things Cosmic.

In that remote æon when the earth was racked by the volcanic tumult of her early geologic birth, the moon was bombarded and gashed by colossal meteoric missiles from the sky; everlastingly sealing her doom as the abode of intelligent life. Thus is strikingly exemplified in the broad field of Cosmic phenomena the cornerstone of the Darwinian doctrine: "Those species which possess a sufficient measure of adaptation to their environment survive: those which fail to so adapt

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* "Mars as the Abode of Life": Percival Lowell, 1908, pp. 23-24.

† Address before the British Association for the Advancement of Science, South Africa. March, 1904.

themselves must perish." In astronomy this inexorable decree of evolution finds its noblest application to that pale, mysterious sister-world of earth's which every twenty-four hours upheaves the mighty deep in its tidal swell and renders less profound the otherwise Stygian gloom of night.

And unto this day she rides the courses of the nocturnal firmament, "with white fire laden," a sterile wanderer whose rocky desolations never woke to the Creator's highest gift to our world—*Life*. As expressed in the fitting eloquence of Scripture:

> "For it shall be established for ever as the moon,
> And as a faithful witness in heaven;"
>
> —Psalms, 89:37.

EXAMINATION OF NEW EVIDENCE ON THE SOLAR CONSTANT. (*)

C. G. ABBOT, F. E. FOWLE, AND L. B. ALDRICH.

Under this title Mr. F. W. Very states in POPULAR ASTRONOMY, Vol. XXV, page 113, "the results [of Abbot, Fowle, and Aldrich in balloon pyrheliometry] will not bear critical examination..... In an undertaking as difficult as this, we can pardon considerable instrumental imperfection, but not the totally incorrect reduction of the observations..... A local application of heat.....was resorted to in order to keep the mercury in the thermometer from freezing. But I find from experiments with a similiar apparatus that the Sun readings under these circumstances *are much too low*, and that a correction of over +50 per cent is required on this account alone..... The results [when thus corrected].....are in very fair agreement with the presumption that the solar constant is about 3.6 gram calories per square centimeter per minute."

It may occur to readers that Mr. Very is pretty positive, considering that he has never experimented with our balloon pyrheliometer or even seen it. He might have had the kindness to point out to us privately what he considered to be our error before publishing these

(*) Published by permission of the Secretary of the Smithsonian Institution.

expressions. If we had been convinced by his array of evidence, we might conceivably have had grace to publish a correction. It is possible, on the other hand, that we might have convinced him that we were right.

We hope that the readers interested will examine our report of the balloon pyrheliometry* and the numerous experiments we made to test and standardize our instrument. If they do so it will be easy for them at the same time to examine Fig. 10, and see how Peppler's observation would suit Mr. Very. They may also care to look over the earlier part of our paper, which he passes over with the epithet "theoretical." For the benefit of those who cannot conveniently do this, we remark that the "local application of heat", objected to by Mr. Very, consisted solely in protecting the sides and back of the outer case of the pyrheliometer with a copper jacket containing water. The water while freezing remained at 0° C, and thus furnished constant temperature surroundings while the instrument was being carried to elevations where air temperatures as low as −40° C were found. The question is whether the instrument read 50 per cent too low when used at −40° C in air at 4 centimeters pressure.

We have tested the balloon pyrheliometer and other similar pyrheliometers over wide ranges of temperatures and pressures. These experiments are so conclusive that we may imitate the positiveness of Mr. Very. No such error as he claims exists. Our results are not "in fair agreement with the presumption that the solar constant is about 3.6 gram calories per square centimeter per minute."

That indeed is the whole trouble with them. Mr. Very tries with this touchstone every paper of every author on the radiation or temperature of the Sun, the radiation, transmission and temperature of the air, the properties of gases, the albedoes of the heavenly bodies, or if there be any other subjects related in any manner to the solar constant of radiation. If the experiments described do not support his favorite value of 3.6 calories, he pronounces them wrong, or invents corrections to fit them to his views.

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*See Smithsonian Miscellaneous Collections, Vol. 65, pp. 1-55.

THE FRAUNHOFER G GROUP AND THE HYDROCARBON BAND.

FRANCES LOWATER.

At the meeting of the Astronomical Club of the Yerkes Observatory on August 3, attention was called to the preliminary report of Professor Newall, Mr. Baxandall and Mr. Butler, on the identification of the Fraunhofer G group with the hydrocarbon band. This band is found in the spectrum of the candle flame and has its head at $\lambda 4314$. They made that report at the meeting of the Royal Astronomical Society held on June 9, the proceedings of which were published in *The Observatory* for July, 1916.

As early as 1895 the probable identity of the Fraunhofer G group with the hydrocarbon band had occurred to Professor Newall; at the solar eclipse in 1898 the peculiar difference between the solar spectrum and the spectrum of the flash appeared to him to consist in the absence of lines in the G group; these missing lines he attributed to the hydrocarbon band.

In 1914 Mr. Baxandall independently arrived at the identity of the Fraunhofer G group and the hydrocarbon band, comparing the solar spectrum with the band spectrum, as given by Eder and Valenta.

Mr. Butler has done experimental work to confirm this identification. Of all the bands in the Swan Spectrum, he found this band the most sensitive to varied conditions.

Other work on the changes in this band with varied conditions has been done by Professors Fowler and Strutt.*

The points at issue in this investigation were:

(a) the identity of the hydrocarbon band with lines in the G group;

(b) the difference between the solar spectrum and the spectrum of the chromosphere; whether the latter is a complete reversal of the former, or differs from it at least in part by the absence of this hydrocarbon band.

Much interest is attached to these questions. If this hydrocarbon band is included in the solar spectrum, but is absent from the flash spectrum, we know not merely that a second compound exists in the sun (cyanogen having long been known to be there), but we have indications of its distribution in the solar atmosphere; its absence from

* Proc. Roy. Soc. Vol. 86, p. 116, (1911).

the flash would show that it does not extend beyond the reversing layer.

A matter of further interest connected with the subject lies in the part played by the G group in typical stellar spectra; for its presence and its variations form some of the important criteria of the classes from F5 to K2.

The interest aroused by the subject of this report led the writer to make a careful comparison of the lines in the three spectra with one another, namely the ordinary solar spectrum, the spectrum of the flash and the spectrum of the hydrocarbon band, both by their photographs and their wave-lengths.

Comparison of the Three Spectra by Photographs.

A sharp comparison of the three spectra by hitherto published photographs is not practicable. However, a comparison of the solar spectrum and the flash spectrum can be made by means of the spectrum of the cusp, photographed by Professor Edwin B. Frost at Wadesboro, N. C., at the solar eclipse in 1900.* The photograph is reproduced in Plate VIII, magnified about four and a half times.

We see at the upper edge the spectrum of the light emitted by the chromosphere; below, the usual absorption spectrum of the sun. Many of the dark lines can be traced directly into the bright lines of the chromosphere; others are much more difficult to trace; considerable differences in intensity of the same lines in the sun and chromosphere will be observed.

Comparison of the Three Spectra by Their Wave-Lengths.

The identification or differentiation of the three spectra was made more precisely by comparing the wave-lengths of the lines.

For the ordinary solar spectrum, of course, Rowland's† values were used.

For the flash spectrum the wave-lengths used were those obtained by Professor S. A. Mitchell ‡ in Spain at the eclipse in 1905. For this part of the spectrum he used a parabolic grating of five feet focal length, and ruled with 14438 lines to the inch; as he used parallel light and no slit, the scale of his photographs gave 10.8 angstroms to 1 mm. In identifying the flash lines with Rowland's solar lines, he blended in some cases two or more solar lines, which were too close together to be resolved on his photographs.

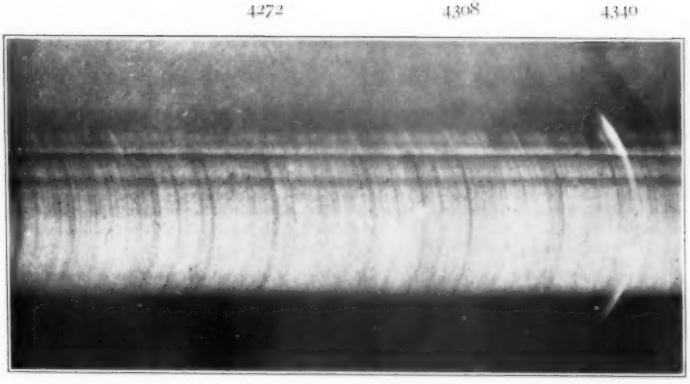
The wave-lengths of the lines of the hydrocarbon band were those

* Astrophys. Jour., vol. 12, p. 307 et seq. (1900).

† "Preliminary Table of Solar Spectrum Wave-lengths" and Astrophys. Journal, vol. 6, p. 384 et seq. (1897).

‡ Astrophys. Journal, vol. 38, p. 407 et seq. (1913).

PLATE VIII.



The Cusp Ten Seconds after Totality.

Portion of the Spectrum photographed by Edwin B. Frost at the Solar Eclipse in 1900.

determined by Professors Eder and Valenta* from the blue cone of the oxy-coal-gas flame, by means of a Rowland concave grating of 15 feet radius of curvature, and ruled with 13000 lines to the inch. They photographed the spectrum in the second order; thus their scale gave approximately 2 angstroms to 1 mm. For good sharp lines they state their error of measurement as not greater than from 0.01 to 0.02; for less well defined lines as roughly 0.03 angstrom.

As is well known, the scale of Rowland's photographs was approximately 1 angstrom to 1 mm.

DESCRIPTION OF THE TABLE.

The first column contains Rowland's values of the wave-lengths of the solar lines, most nearly identical with the lines of the flash, or with those of the hydrocarbon band; it starts with the line at the head of the band. The wave-lengths, connected by a brace on the right-hand side of the column, are those blended by Professor Mitchell in identifying the flash lines with the solar lines, his wave-lengths for the blend being directly to the right of the brace. Braces on the left-hand side of the column are Rowland's. "S" indicates Rowland's standard lines. Solar lines represented neither in the hydrocarbon band nor the flash are omitted from the table; there are many such. In the second column are the intensities and characters, given the lines by Rowland. The third column contains the substances to which he assigned the lines.

The fourth column contains the wave-lengths of the spectrum of the chromosphere, obtained by Professor Mitchell at the eclipse in 1905. In the fifth column are the intensities given the flash lines by him. The sixth column gives the substances which, he considers, are the sources of the lines in the chromospheric spectrum.

The seventh column contains the wave-lengths of all the lines of the hydrocarbon band, obtained by Professors Eder and Valenta; and the eighth column, the intensities of those lines.

The ninth column gives the differences between the wave-length of each line of the band and that of the nearest solar line. "N" is brought forward from Rowland's list of characters to call attention to the fact that he marked those particular lines "N", indicating that "the line is not clearly defined, or is much weaker than it should be for its breadth;" ("such a line may generally be considered as composed of two or more lines too close together to be separated"). This characterization of these lines should be borne in mind in considering their identity. It may well be that one of the components of such a line has its origin in a hydrocarbon, and the other in a metal or elementary gas. We should also take into account the fact, that lines of the band

*"Spectralanalyse der Leuchtgasflamme" (1898).

TABLE—COMPARISON OF LINES

SOLAR SPECTRUM				FLASH SPECTRUM			HYDROCARBON BAND		Differences in λ	
	Wave-length		Intensity and Character	Substance in Reversing Layer	Wave-length	Int.	Substance in Chromo-sphere	Wave-length	Int.	Band—Sun	
	4314.25		3	Sc	4314.24	10	Sc	4314.26	3	— .01	
	13.80		2Nd?					13.71	4	— .09	N
	13.19		1N					13.14	4	— .05	N
	13.03		3	Ti	12.98	10	Ti	13.05	4	+ .02	
	12.87		0					12.85	3	— .02	
	12.66		00					12.63	3	— .03	
	12.31		1					12.32	6	+ .01	
	12.25		2		12.24	0		12.18	6	— .07	
	11.88		2N					11.78	3	— .10	N
	11.67	1.72	2		11.72	1	Ti-Ce-				
	11.61		2					11.57	7	— .04	
	11.33		2					11.28	4	— .05	
	11.15		1					11.11	2	— .04	
	10.86		2		10.92	0	Ce				
	10.72		0					10.73	3	+ .01	
	10.54		2		10.55	0	Ti	10.51	4	— .03	
	10.27		2					10.19	8	— .08	
	10.07		0								
	09.79		1		09.78	4	Y	09.79	3	.00	
	09.54		3	Fe				09.49	4	— .05	
	09.29		0					09.25	4	— .04	
	09.20		2	Fe							
	09.06	9.00	1		09.05	0	Zr-Fe				
	08.76		2Nd?								
	08.94		000					08.94	4	.00	
	08.60		00					08.63	3	+ .03	
	08.33		1								
	08.21		0					08.26	3	+ .05	
Gs	08.08		6	Fe	08.01	15	Fe-Ti	08.06	3	— .02	
	07.91		3	Ca			Ca				
	07.72		2Nd?					07.72	5	.00	N
		7.59			07.55	1					
	07.46		2N					07.46	3	.00	N
	4306.86		2		4306.89	2	Ce-Nd	4306.91	4	+ .05	

4306.76		0					4306.79	4	+ .03	
06.52		00N		4306.43	0	V-Gd				
06.30		2N					06.24	3	— .06	N
06.08		4	Ti							
06.01	6.01	1		05.98	4d	Ti-Sc-Pr	06.02	4	+ .01	
05.87		2								
05.61		3	Fe,Sr,Ti,Cr	05.62	3	Sr	05.59	3	— .02	
05.48		1					05.52	3	+ .04	
05.27		1					05.15	1	— .12?	
05.01		0N								
04.88		0	Zr				04.91	1	+ .03	
04.73	4.67	2		04.65	1	Nd-Fe	04.69	3	— .04	
04.55		1					04.50	2	— .05	
04.10		4					04.06	8	— .04	
03.99	3.91	2		03.93	1	Nd-Er				
03.75		1					03.80	1	+ .05	
03.88		0								
03.58	3.42	1N		03.41	3d	Fe-	03.47	1	— .11	N
03.34		2								
03.25		0					03.20	1	— .05	
03.07		1N					02.99	3	— .08	N
02.91		2N					02.84	4	— .07	N
s 02.69		4	Ca	02.75	2	Ca				
02.46		2					02.40	4	— .06	
02.35		2	Fe							
02.08		2	Ti	02.10	5	Ti-Zr				
01.90		0Nd?					01.90	2	.00	N
01.26		4		01.24	2	Ti	01.23	3	— .03	
01.16		2	Ti				01.11	2	— .05	
00.73		2	Ti				00.68	4	— .05	
00.48		1N					00.44	3	— .04	N
00.38	0.31	0	Mn	4300.31	15	Ti-Mn-Ce				
4300.21		3	Ti							
4299.99		1N					4300.02	1	+ .03	N
99.41		4	Ti,Fe	4299.43	3	Ti,Fe				
99.30		1					4299.30	3	.00	
4299.15		3	Ca	4299.18	3	Ca				

SOLAR SPECTRUM Wave-length		Intensity and Character	Substance in Reversing Layer	FLASH SPECTRUM Wave-length	Int.	Substance in Chromo-sphere	HYDROCARBON BAND Wave-length	Int.	Differences in λ Band—Sun	
4298.97		2					4298.94	4	— .03	
98.83	8.90	2	Ti	98.88	2	Ti—				
98.36		1		98.33	1					
98.14		1	Ti				98.06	5	— .08	
97.91		0	Cr,V	97.90	1	Cr-V-Pr	97.86	1	— .05	
97.68		1N					97.61	2	— .07	N
97.45		2								
97.37		2					97.38	4	+ .01	
97.20	7.29	1	Cr	97.23	1	Cr-Gd				
97.11		2					97.09	4	— .02	
96.93		0N								
96.84	6.80	1	Zr?	96.83	5	Fe,Zr-Ce	96.82	4	— .02	
96.74		3								
96.38		0N					96.41	1	+ .03	N
96.24		0	La							
96.04	6.06	1	Ni	96.07	3d	Ti-V-La-Gd				
95.91		2	Cr,Ti							
95.38		3Nd?					95.34	3	— .04	N
95.19	5.29	3d?		95.25	2	Dy-	95.18	2	— .01	
94.94		2	Zr	94.96	2	Zr-Sc				
94.30	4.27	5	Fe							
94.20		2	Ti	94.23	15	Ti,Fe				
s 93.27	3.24	3					93.26	5	— .01	
93.19		2		93.19	3d	Zr-				
92.45		2								
92.29	2.29	2		92.25	3d	V-Mn				
92.21		1					92.18	6	— .03	
92.14		0	Cr,V							
91.63		2	Fe							
91.38		1								
91.28	1.30	2	Ti	91.30	3d	Ti-Fe	91.31	5	+ .03	
91.11		3	Ti				91.13	3	+ .02	
91.04		1								
4290.38		2	Ti	4290.33	15	Ti				

s	4289.88		5	Cr	4289.78	15	Cr			
s	89.52		4	Ca			Ca			
	89.36		0000							
								4289.28†	1	+ .04
	89.24		2	Ti	89.25	2	Ti			
								89.21†	1	— .03
	88.89		00N		88.85	1	Ce	88.81	2	— .08 N
	88.31		1	Ti,Fe						
	88.15	8.13	1	Ni	88.11	4N	Ti-V			
	88.04		2	Ti						
	87.16	7.11	2	La	87.05	1	La—			
	87.03		1					87.03	1	.00
	86.63		3N		86.58	1	V	86.59	4	— .04 N
	86.35		1					86.32	3	— .03
	86.24		0					86.23	3	— .01
	86.17		2	Ti-						
	85.97	6.07	1		86.04	2	Ti—			
	85.69		1					85.66	2	— .03
	85.60	5.61	3	Fe	85.59	2	Fe-Ce			
	85.52		1					85.56	2	+ .04
	85.16		2	Ti-				85.10	1	— .06
	84.99	5.01	1		84.96	1	Ti-Ni-Zr	85.02	1	+ .03
	84.84		1	Ni						
	84.38	4.34	2Nd?		84.30	2N	Cr-V-Mn			
	84.22		0	Mn,V				84.21	2	— .01
s	83.17		4	Ca	83.11	3	Ca			
	82.56		5	Fe	82.60	5	Fe			
	82.13		2N		82.10	2		82.11	2	— .02 N
	81.26		2	Mn	81.23	2	Mn	81.16	1	+ .05?
	81.11		1					81.14	1	+ .03
	80.94	0.86	1		80.88	1	Sa,Gd			
	80.79		0							
	80.56		1	Cr	80.57	1	Cr			
	80.37		1N	—,Fe				80.33	3	— .04 N
	80.19	0.20	1		4280.14	1	La,Ti—	4280.15	3	— .04
	4280.03		1	Fe,—						

†Probably hidden in the solar spectrum by Ti line between them.

	SOLAR SPECTRUM Wave-length		Intensity and Character	Substance in Reversing Layer	FLASH SPECTRUM Wave-length	Int.	Substance in Chromo-sphere	HYDROCARBON BAND Wave-length	Int.	Differences in λ Band—Sun	
	4279.87	9.76	2Nd?		4279.81	2	Sa—	4279.86	3	— .01	N
	79.64		2								
	79.48		000N					79.52	3	+ .04	N
	79.01	8.96	1N	Ti—	78.92	0N	Ti-Mn-Ce				
	78.84		00								
	78.39		3	Fe-Ti	78.36	2	Ti-Fe				
	77.69	7.65	2d?		77.60	1	Zr—				
	77.54		0	Zr							
	77.15		1N	V—	77.15	1	V				
	76.84		2	—Zr	76.80	1	Zr-Er				
	75.81		0								
	75.71	5.76	0		75.70	2	La-Ce	75.72	2	+ .01	
	75.41		0N					75.45	3	+ .05	N
	75.12		0					75.03	1	— .09	
s	74.96		7d?	Cr	74.93	20	Cr				
	74.35		2N					74.34	3	— .01	N
	74.10	4.21	1		74.15	0					
	74.04		1	Fe?				74.01	3	— .03	
	73.95		0								
	73.84		00					73.89	3	+ .05	
	73.64		2N	Zr				73.58	2	— .06	N
	73.48	3.55	3N	Fe	73.52	3	Zr-Fe				
	73.05	2.88	1d?		72.93	1	Nd-V				
	72.70		1	Ti—							
s	71.93		15	Fe	71.93	10	Fe				
	71.32		6	Fe	71.32	4	Fe				
	70.33		1N	Ti—	70.35	1	Ti-Ce	70.24	1	— .09	N
	70.12		00								
	69.90		2		69.83	1	V	69.91	2	+ .01	
	69.62		0	La	69.68	1	La				
	68.78		0		68.77	2	V				
	68.27		1N		4268.20	1	Zr—				
	4268.14		0	Zr				4268.18	3	+ .04	

s	4267.98	7.95	3	Fe	4267.92	3	Fe—			
	67.95									
	67.90		1					4267.86	4	— .04	
	67.54		2N		67.55	0		67.52	2	— .02	N
	67.12		3	Fe							
	66.89	7.03	0	Cr	66.98	1N	Fe-Nd				
	66.78		0								
	66.08		2	Mn	66.10	1	Mn				
	65.42		2	Fe	65.36	0	Fe,V				
	64.90		2	Fe							
	64.62		1								
	64.37	4.52	3	Fe	64.48	1d	Fe—				
	64.13		1								
	63.42		0								
	63.29	3.32	2	Ti,Cr	63.35	1	Ti-Cr				
	62.14		1								
	62.09	2.00	1		61.98	2	Cr-Nd	62.10	3	+ .01	
	61.89		2					61.85	3	+ .04	
	61.68		2	—Cr				61.64	3	— .04	
	61.50	1.52	0	Cr,Mn	61.58	1	Cr-Mn				
	61.38		2					61.30	3	— .08	
	60.64		10	Fe	60.67	8	Fe				
	60.28	0.23	3d?	Fe	60.27	2d	Fe				
	60.15		2	Fe							
	59.46		1Nd?								
	59.30		0					59.36	1	+ .06	
	59.25	9.26	0		59.23	1N	Mn-Fe-V	59.23	1	— .02	
	59.11		2	Fe							
	58.88		1N					58.87	1	— .01	N
	58.77		2	Fe	58.74	1	Fe,Ti				
	58.64		0N					58.63	1	— .01	N
	58.48		2	Fe							
	58.22	8.34	1N		58.37	4N	Zr-Fe				
	58.20		0	Zr							
	57.82		2	Mn	57.81	1	Mn				
	57.52		00		57.49	0	V				
	56.58		00	Zr	56.60	1	Zr-Sa				
	4255.99		2N	Fe	4256.05	1	Ce-Fe	4255.91	3	— .08	N

SOLAR SPECTRUM				FLASH SPECTRUM			HYDROCARBON BAND		Differences in λ	
	Wave-length		Intensity and Character	Substance in Reversing Layer	Wave-length	Int.	Substance in Chromosphere	Wave-length	Int.	Band—Sun	
	4255.79		1N					4255.72	3	— .07	N
	55.66		1	Fe,Cr							
	55.41	5.42	1		4255.46	0	Fe-Cr-V-Zr	55.38	3	— .03	
	55.13		2d?	Fe				55.14	3	+ .01	
s	54.50		8	Cr	54.52	15	Cr				
	53.52		00		53.55	1	Ce,Gd				
	53.36		1								
	53.16	3.15	1		53.12	0					
	52.92		1N								
	52.78		0N								
	52.62	2.70	00N		52.62	3	Cr-Nd				
	51.90		00	Ti							
	51.78	1.84	00	Ti	51.85	2	Mn-Gd				
s	51.07		1								
s	50.94	0.96	8	Fe	51.01	5	Fe				
s	50.29		8	Fe	50.32	4	Fe				
	49.80		2N					49.78	3	— .02	N
	49.65		1N		49.68	1		49.64	3	— .01	N
	49.10		2N					49.08	3	— .02	N
	48.88		2N		48.84	3N	Ce	48.91	3	— .03	N
	48.38		2	Fe	48.42	2	Fe				
	47.59		4	Fe	47.57	1	Fe,Nd				
	47.00		5	Sc	47.07	30	Sc				
	46.25		2	Fe	46.22	1	Fe				
	45.52		2								
	45.42	5.45	4	Fe	45.44	2	Fe—				
	44.89		00		44.80†	1N					
	43.98		2								
	43.71	3.75	1		43.82	1d	Fe-Zr-Gd				
	43.61		3	Fe							
	43.52		1					43.54	6	+ .02	
	43.36		1d?		43.32	2	Nd				
	42.90		2	Fe	4242.91	1	Cr-Fe				
	4242.62		2					4242.67	3	+ .05	

4242.54		2					4242.53	3	— .01	
42.44		0		4242.40	3N	Cr-Mn-Er				
41.28		2	Fe-Zr	41.26	1	Zr-Pr				
40.87		1	Cr							
40.62	0.64	1		40.68	0d	Zr-Cr-Fe				
40.54		2	Fe							
40.12		1								
40.01	30.99	3	Fe	40.05	3	Fe-Ce-Nd				
39.89		3	Fe,Mn							
38.97		5	Fe	39.02	2	Fe-Gd				
38.56		1Nt?	La	38.55	2	La				
38.19		3	Fe	38.15	2	Fe-Sc	38.22	1	+ .03	
37.41		1								
37.34		3	Fe							
37.24	7.25	1		37.24	2d	Fe-Sa	37.28	8	+ .04	
37.12		0								
36.97		1d								
36.71		00N		36.72	0	Zr				
36.43		1	Ni				36.39	3	— .04	
36.28		1		36.24	6	Zr	36.25	3	— .03	
36.11		8	Fe			Fe-Y				
35.99	5.94	0		35.98	1	V-Y				
35.89		0								
35.45	5.39	3	Mn							
35.30		2	Mn	35.37	3	Mn-Nd				
34.38		0N		34.35	1	Nd,Ce				
33.77		6	Fe	33.82	1	Fe				
33.33		4	Mn	33.40	20	Fe-Cr				
33.09		1N	—V				33.14	1	+ .05	N
32.76		00	V							
32.62	2.64	00		32.60	1	V-Nd				
32.54		00								
31.18		4N	Ni	31.18	2	La-Ni	4231.13	4	— .05	N
4230.41		00Nd?		4230.45	0	Er				

†Not identified with solar line by Mitchell.

	SOLAR SPECTRUM Wave-length		Intensity and Character	Substance in Reversing Layer	FLASH SPECTRUM Wave-length	Int.	Substance in Chromo-sphere	HYDROCARBON BAND Wave-length	Int.	Differences in λ Band—Sun	
	4230.08		1N								
	29.93	9.86	3	Fe	4229.87	3d	Fe-V-Sa	4229.93	3	.00	
	29.68		2	Fe							
	28.88		1		28.84	1					
	28.48		00N		28.34†	0	Nd				
	28.26		000								
	27.92		0	Zr	27.88	2	Zr-V-Ce-Nd				
gs	26.90		20d?	Ca	26.90	25	Ca				
	25.49		000		25.45	2	V-Sa-Pr				
	25.02		2N					25.00	3	— .02	N
	24.67	4.81	3	Cr-Fe	24.83	1d	Cr				
	24.34		4	Fe	24.35	2	Fe-V				
	23.74		1								
	23.64	3.69	1		23.64	1		23.66	4	+ .02	
	23.40		0								
	23.26		1N								
	23.06	3.11	00N		23.10	1	Ce-Pr-				
	22.89		0	Cr							
	22.77		0								
s	22.38		5	Fe	22.38	2	Fe				
	20.81		00		20.78	2	Y-Sa				
	20.51		3	Fe	20.48	2	Fe				
	19.58		3								
	19.52	9.54	4	Fe	19.56	3	Fe—				
	18.88		3N		18.84	1	V	18.82	4	— .06	N
	18.56		1Nd	—Zr	18.52	1	Zr,Er				
	17.72		5d?	La,Fe-Cr	17.70	2	La-Cr				
	17.36		1		17.28	2	Gd	4217.32	3	— .04	
	16.35		3d?	Fe	16.32	1	Fe				
s	16.14††		1	C							
s	15.70		5d?	Sr	15.88	40	Sr				
	14.20		00		14.22	0	C				
	4213.81		3	Fe	4213.81	3N	Fe-C				

4213.01		00	C							
12.80	2.84	3N	Cr?	4212.89	1	Cr-C	4212.75	3	— .05	N
12.05		2	Zr—	12.04	3	Zr-C				
11.51	1.46	0N	C-Cr	11.41	0	Nd-C				
11.35		00N								
11.13		3N					11.07	3	— .06	N
10.86		000	C	4210.92	0	Zr-C				
10.56		3								
10.49	0.52	4	Fe	10.53	3d	Fe-Sa				
09.98		1	V							
09.91	9.84*‡	0	Cr	09.87	0	V-Cr-				
09.76		0								
09.66		0	C							
09.14		1	Zr	09.11	4	Zr				
08.77		3	Fe	08.75	0	Fe				
08.27		00		08.30	0	C				
07.57		1N	C							
07.29	7.36	3	Fe	07.40	1d	Fe-C				
06.86	7.03	3	Fe	06.99	2d	Fe-Pr				
06.74		1								
06.46		0		06.44	0					
06.06		00					06.05	2	— .01	
05.70		2		05.70	1	Nd				
05.24	5.21	1		05.22	8	V-Eu				
05.19		1								
04.92		2					4204.91	2	— .01	
04.88		1		04.84	0	Y				
04.16	4.14	4	La	04.14	2	Fe-La				
04.10		3	Fe							
03.73		2	Cr	03.75	0	Cr				
03.10		0N		03.15	3	Ce-Sa				
02.67		00								
02.51	2.57	0Nd?		02.59	0	V-C				
s 4202.20		8	Fe	4202.29	6	Fe				

†λ 4228.35, Nd in arc and spark. Not identified with solar lines by Mitchell.
††"First line in first head of carbon band." (Rowland).
*In all blends marked * the writer is uncertain which lines were blended. ‡Three lines blended.

	SOLAR SPECTRUM				FLASH SPECTRUM			HYDROCARBON BAND		Differences in λ
	Wave-length		Intensity and Character	Substance in Reversing Layer	Wave-length	Int.	Substance in Chromosphere	Wave-length	Int.	Band—Sun
	4201.87		1	Fe,Ni-Mn	4201.90	0	Mn-Ni			
	01.09		3	Fe						
	00.95		1	Ti						
	00.86	0.85	0		00.83	3N	Ti-Fe-C			
	00.76		1					4200.73	3	— .03
	00.61		1	Ni						
	4200.15		2	Fe	4200.10	1	Fe-Nd			
s	4199.27		5	Zr-Fe	4199.25	5	Zr-Fe			
	98.80		3	Fe	98.85	3	Ce-Fe-C			
	98.68		00					4198.66	1	— .02
	98.49		4	Fe						
	98.40	8.40	4		4198.41	5d	Fe—			
	98.22		2	Fe						
	97.81		00		97.80	1	C			
s	97.26†		2	C	97.27‡	3	C			
	96.70		2	La	96.75	2	La			
	95.99		00N							
	95.78		2	Fe-C						
	95.68	5.67*††	1		95.66	2N	Fe-C			
	95.57		00	C						
	95.49		5	Fe						
	95.16		0d?	C						
	95.01	5.06	1	Cr	95.12	2	Nd-Ce			
	94.89		1	C,—				94.87	2	— .02
	94.78		00	C						
	94.65	4.57	0		94.60	1N	C			
	94.47		00	C						
	94.40		00	C						
	93.96		0	C	94.00	1	Ce-C			
	93.61	3.58	00	C	93.58	2d	C			
	93.54		00	C						
	93.07		00Nd?	C	93.11	1	C			
	92.73		2N		4192.70	0	—C			
	4192.26		00	La?				4192.27	1	+ .01

	4192.17		0	Cr	4192.20	0	Cr-C				
	91.84		3	Fe							
	91.60	1.68	6	Fe	91.63	5d	Fe				
	90.87		1Nd?	C,Co	90.85	0	Co-Er-C				
	90.29	0.22	0N	Cr	90.22	2	Er-Mn-C				
	90.15		0N	Mn							
	89.72		2	C,—							
	89.49		0000N		89.58‡‡	1	C				
	88.89		4		88.89	2N	Ti-Nd				
	88.02		3								
	87.94	7.91	5	Fe	87.93	4	Fe-Ti-Ni				
	87.88		0	Zr							
	87.75		2	Fe							
	87.20		6	Fe	87.24	4	Fe				
	86.78		2N	Ce-Zr	86.70	3	Ce-Zr	4186.80	1	— .02	N
	85.94	5.89	0Nd?		85.87	1	C—				
	85.81		00								
s	85.06		4	Fe,Cr	85.05	3	Fe-Nd-C				
	84.64		0								
	84.47	4.32	2		84.35	3d	Ti-Gd-				
	84.16		4								
	83.62	3.57	2N		83.54	2d	V-Zr				
	83.48		1N	Zr							
	82.92		2		82.90	0					
	82.55		3	Fe	82.52	2	Fe				
	82.14		2								
	81.92	1.95	5	Fe	81.97	3d	Fe—				
	81.71		1								
	4180.97		2N	C	4180.98	2	C	4180.99	1	+0.02	N

†"First line in second edge of carbon band." (Rowland).
‡"Second edge of second cyanogen band." (Mitchell).
††Three lines blended.
‡‡Not identified with solar lines by Mitchell.

in the sun, very close to stronger lines from another source, may be, as it were, overshadowed by the stronger lines, and hence the centre of gravity of the line appear to be of longer or shorter wave-length than it really is. In measuring such lines, it is almost impossible to avoid introducing a small error into the wave-length.

Deductions From the Table.

Examination of the ninth column shows that over 53 per cent of the lines of the hydrocarbon band differ in wave-length from Rowland's solar lines by from 0.00 to 0.03 angstrom, and 70 per cent by from 0.00 to 0.04. Considering the difference in the conditions existing in the Sun in the one case, and in the flame in the laboratory in the other, a difference of 0.04 angstrom in wave-length is probably not too great to admit in identical lines. If that be the case, then 70 per cent of the band lines may be identical with lines in the Sun. Of the remaining lines approximately 13 per cent differ by 0.05 angstrom from the nearest solar lines.

The sources of 99 of the 133 lines in the G band, i. e. of 74 per cent of them, were not identified by Rowland; but his "Preliminary Table of Solar Spectrum Wave-lengths" and his "Corrections and Additions" were published before Professors Eder and Valenta published the spectrum of the hydrocarbon band, obtained with large dispersion.

It will also be noticed that 42 of the solar lines, with which the band lines may be identical, are marked "N" by Rowland; 33 of these are not assigned to any source, 1 is assigned to carbon, 1 doubtfully to chromium, and 7 to other metals, but in 3 of the 7 cases another additional source, though unknown, is indicated by Rowland.

Hence we have strong evidence that the hydrocarbon band, with its head at λ 4314, is included in the solar spectrum, the less refrangible part of it being coincident with some of the lines of the Fraunhofer G group.

In regard to the flash spectrum, we find in Professor Mitchell's list 201 lines in the region covered by the hydrocarbon band. Of these 81 per cent are in closer agreement with solar lines than with lines of the band, while about 14 per cent have about equally close identities in the Sun and band. In the latter cases the line of the band is practically identical with the solar line, or the flash line lies between the solar line and the line of the band.

Summary.

No doubt Messrs. Newall, Baxandall and Butler will publish extensive and varied evidence on this identity. Meanwhile the data here presented will confirm their view:

(a) that the hydrocarbon band is included in the solar spectrum,

its lines of longer wave-length forming part of the G group;

(b) that the hydrocarbon band is not in the flash spectrum.

Hence we deduce that the flash spectrum is not a complete reversal of the solar spectrum, and therefore some hydrocarbon is contained in the reversing layer, but does not extend into the chromosphere.

Further reference to Professor Mitchell's * table of chromospheric wave-lengths shows that all the heads of the second cyanogen band, except the first, are included in the spectrum of the flash; this first head at λ 4216.14 was doubtless blended in his photographs with the Fe line at λ 4216.32; though not actually stated, the idea is suggested by his foot note, giving the wave-length of the first head of the band. We thus observe that cyanogen is not limited to the reversing layer, but extends into the chromosphere.

Yerkes Observatory.
August 1916.

* Astrophys. Journ. vol. 38, pp. 444-446.

ORION.

When golden Capella is reigning on high
And Sirius sparkles with fiery light,
The suns of Orion bespangle the sky
Like jewels set deep in the vast dome of night;

There Rigel and Betelgeuze glitter and glow,
Bellatrix burns dimly with wan yellow blaze,
And stars of the belt shine as gems in a row
Above the faint gleam of the Nebula's haze;

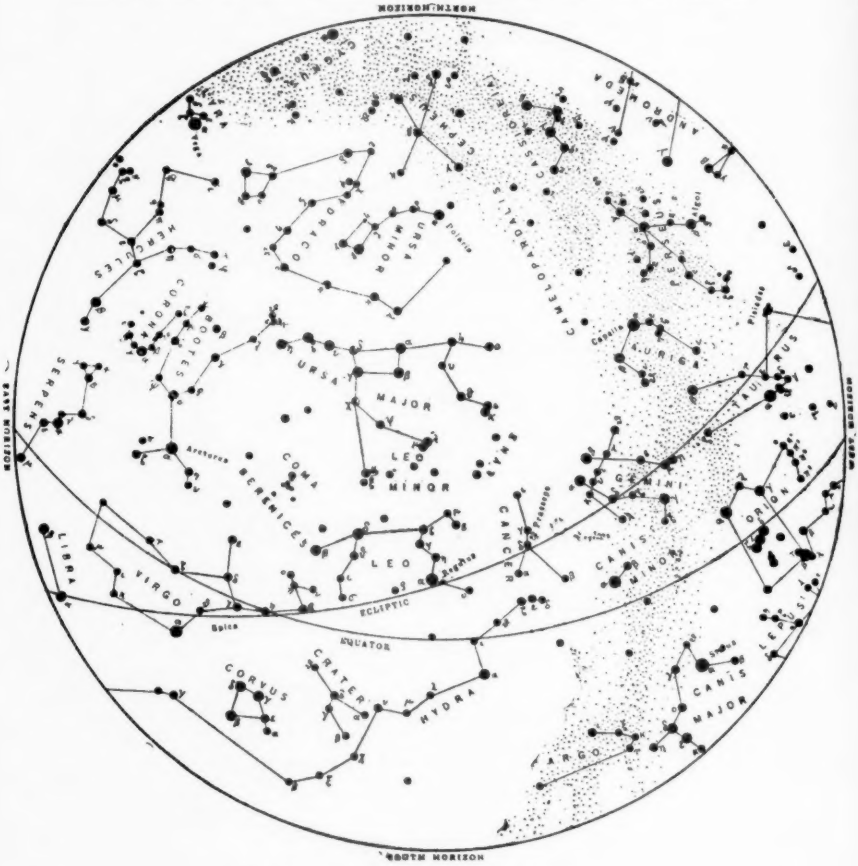
Orion the Hunter! —gigantic and bright,
Below the red glint of Aldebaran's eye,
When Sirius sparkles with fiery light
And golden Capella is reigning on high.

CHARLES NEVERS HOLMES.

Newton, Mass.,
41 Arlington St.

PLANET NOTES FOR APRIL 1917.

The sun will move by a northeasterly course from Pisces into Aries during the month. At the end of the month it will be nearing the region of the Pleiades.



THE CONSTELLATIONS AT 9:00 P. M. APRIL 1.

The phases of the moon for April are as follows:

Full Moon	April 7 at 8 P.M.	C.S.T.
Last Quarter	14 " 2 A.M.	"
New Moon	21 " 8 P.M.	"
First Quarter	28 " 11 A.M.	"

Mercury is an evening star during the entire month. Its distance from the sun is gradually increasing. On April 24 it will reach a point of greatest elongation. On this date it may be seen in the evening sky about an hour and a half after sunset. It will be found in the constellation of Taurus near the Pleiades.

Venus will reach superior conjunction on April 25. On this date it will be at its greatest distance from the earth. It will not be visible during the month.

Mars will not be visible during the month.

Jupiter may be seen in the evening sky. On April 30 it will set a little less than a half hour later than sunset. Because of its brightness, which is about —1.6 magnitude, it may be seen in the evening twilight during the latter part of the month It will be found in the constellation of Aries.

Saturn will still be in a fine position for evening observation. It may easily be found in the constellation of Gemini, being almost on a line drawn from Castor to Pollux and continued about one and a half times the distance between these two stars. It will cross the meridian before sunset at the end of the month. Its stellar magnitude on April 15 is +0.3.

Uranus may be seen in the morning sky. It may be found with the aid of a small telescope in the constellation of Capricorni.

Neptune may be found with the aid of a telescope in the evening sky in the constellation of Cancer.

Occultations Visible at Washington.

[*From the American Ephemeris*].

Date 1917	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle f'm N.	EMERSION. Washington M.T.	EMERSION. Angle f'm N.	Duration
			h m	°	h m	°	h m
Apr. 1	54 Cancri	6.3	5 59	100	7 25	335	1 26
2	o Leonis	3.8	10 27	164	11 31	222	1 4
3	155 B. Leonis	6.5	7 42	113	9 6	328	1 24
10	σ Scorpii	3.1	14 53	116	16 15	244	1 22
12	70 B. Sagittarii	6.4	14 38	22	15 13	352	0 35
14	σ Capricorni	5.5	14 4	113	14 58	260	0 53
27	209 B. Gemin.	6.2	10 20	80	11 11	272	0 51

Saturn's Satellites for April, 1917.

[*From the American Ephemeris.*]

CENTRAL STANDARD TIME.

E = eastern elongation; W = western elongation;
I = inferior conjunction; S = superior conjunction.

I. Mimas. Period $0^d\ 22^h.6$.

Apr. 1 12.8 W	Apr. 8 14.4 E	Apr. 13 7.5 E	Apr. 21 7.8 W
2 11.4 W	9 13.0 E	17 13.3 W	25 13.6 E
3 10.0 W	10 11.7 E	18 12.0 W	26 12.3 E
4 8.6 W	11 10.3 E	19 10.6 W	27 10.9 E
5 7.3 W	12 8.9 E	20 9.2 W	28 9.5 E
			29 8.1 E

II. Enceladus. Period $1^d\ 8^h.9$.

Apr. 1 3.2 E	Apr. 7 23.7 E	Apr. 14 20.2 E	Apr. 23 1.6 E
2 12.1 E	9 8.6 E	16 5.1 E	24 10.5 E
3 21.0 E	10 17.5 E	17 14.0 E	25 19.4 E
5 5.9 E	12 2.4 E	18 22.9 E	27 4.3 E
6 14.8 E	13 11.3 E	20 7.8 E	28 13.2 E
		21 16.7 E	29 22.1 E

Saturn's Satellites for April, 1917—Continued.

III. Tethys. Period $1^d\ 21^h.3$.

Apr. 1 12.4 E	Apr. 9 1.6 E	Apr. 16 15.0 E	Apr. 24 4.3 E
3 9.7 E	10 22.9 E	18 12.3 E	26 1.6 E
5 7.0 E	12 20.3 E	20 9.6 E	28 4.9 E
7 4.3 E	14 17.6 E	22 7.0 E	29 20.3 E

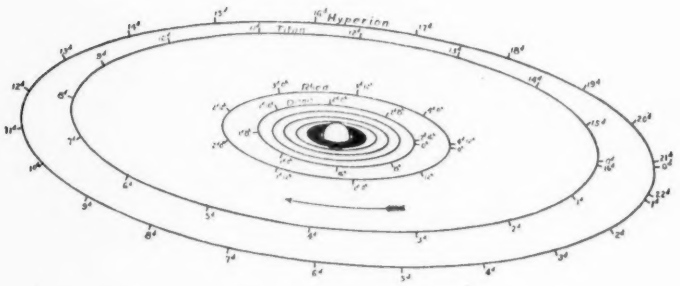
IV. Dione. Period $2^d\ 17^h.7$.

Apr. 1 7.1 E	Apr. 9 12.2 E	Apr. 17 17.3 E	Apr. 25 22.5 E
4 0.8 E	12 5.9 E	20 11.1 E	28 16.2 E
6 18.5 E	14 23.6 E	23 4.8 E	

V. Rhea. Period $4^d\ 12^h.5$.

Apr. 4 1.0 E	Apr. 13 2.0 E	Apr. 22 3.0 E	Apr. 26 15.5 E
8 13.5 E	17 14.5 E		

South



North

Apparent orbits of the Seven Inner Satellites of Saturn, at date of opposition, January 17, 1917, as seen in an inverting telescope.

VI. Titan. Period $15^d\ 23^h.3$.

Apr. 4 5.2 W	Apr. 12 11.7 E	Apr. 20 4.5 W	Apr. 28 11.2 E

VII. Hyperion. Period $21^d\ 7^h.6$.

Apr. 11 7.6 W	Apr. 20 21.9 E

VIII. Iapetus. Period $79^d\ 22^h.1$.

Apr. 18 19.3 I

IX. Phoebe. Period $523^d\ 15^h.6$.

	α Ph. $-\alpha$ Sat.	δ Ph. $-\delta$ Sat.		α Ph. $-\alpha$ Sat.	δ Ph. $-\delta$ Sat.
	m s	′ ″		m s	′ ″
Apr. 2	+2 0.5	−2 6	Apr. 16	+1 45.2	−1 24
4	1 58.5	2 0	18	1 42.8	1 18
6	1 56.4	1 54	20	1 40.4	1 12
8	1 54.3	1 48	22	1 37.9	1 6
10	1 52.1	1 42	24	1 35.4	1 0
12	1 49.8	1 36	26	1 32.8	0 54
14	+1 47.5	−1 30	28	1 30.2	0 48
			30	+1 26.6	−0 42

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by Lois N. Wilson at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1917 April
	h m	° ′		d h	d h d h d h d h d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8	3 4
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	6 14; 14 6; 21 22; 29 14
U U Androm.	38.5	+30 24	10.7—11.9	1 11.7	2 2; 9 13; 16 23; 24 10
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	7 23; 15 10; 22 22; 30 9
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	2 20; 15 1; 21 4; 27 7
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	7 5; 14 8; 21 12; 28 15
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	6 22; 13 19; 20 16; 27 12
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	4 16; 11 20; 19 0; 26 4
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	7 15; 16 9; 25 4
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	5 0; 12 23; 20 21; 28 20
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	5 9
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	4 21; 10 18; 22 2; 27 19
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	2 9; 9 4; 22 18; 29 13
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	6 0; 13 21; 21 19; 29 17
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	2 7; 10 15; 18 22; 27 5
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	2 10; 10 7; 18 5; 26 2
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	5 19; 19 0
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	5 17; 15 4; 24 14
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	7 10; 19 11
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	5 21; 12 13; 19 5; 25 21
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	2 19; 10 23; 19 4; 27 8
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	2 23; 9 0; 21 1; 27 1
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	7 23; 16 15; 25 7
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	5 18; 16 4; 26 14
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	4 3; 12 3; 20 4; 28 4
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	1 1; 12 12; 23 23; 29 17
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	4 19; 10 10; 21 15; 25 5
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	5 23; 14 4; 22 19; 30 14
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	6 7; 13 16; 21 7; 28 22
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	8 7; 20 12
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	2 22; 10 2; 17 6; 24 10
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	7 8; 14 4; 21 0; 27 19
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	7 7; 16 14; 25 21
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	5 5; 11 19; 18 10; 25 1
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	7 20; 16 5; 24 15
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	4 10; 10 20; 23 17; 30 3
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	7 9; 14 15; 21 22; 29 4
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	3 1; 11 4; 19 7; 27 10
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	7 2; 16 14; 26 1
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	6 10; 13 6; 20 3; 26 23
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	3 15; 9 13; 21 10; 27 8
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	6 18; 13 11; 20 5; 26 23
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	3 13; 10 0; 18 10; 25 20
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	4 3; 10 18; 23 23; 30 13
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	7 14; 16 10; 25 5
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	6 3; 13 11; 20 18; 28 2
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	1 16; 8 11; 22 0; 28 19
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	7 23; 15 11; 22 23; 30 11
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.2	5 3; 14 17; 24 7
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	4 2; 11 13; 18 23; 27 10
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	4 6; 11 6; 18 5; 25 5

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1917 April
	h m	° ′		d h	d h d h d h d h d h
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	6 15; 13 12; 20 10; 27 8
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.4	3 22; 12 8; 20 18; 29 4
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	4 11; 12 3; 19 18; 27 10
SW Ophiuchi	16 11.1	− 6 44	9.2—10.0	2 10.7	7 7; 14 15; 21 23; 27 7
SX Ophiuchi	12.6	− 6 25	10.5—11.2	2 01.5	6 2; 14 8; 22 14; 30 20
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	7 16; 16 12; 25 8
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	9 16; 20 17; 30 10
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	6 7; 13 2; 19 21; 26 16
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	5 9; 13 18; 22 3; 30 13
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	2 11; 8 14; 20 22; 27 1
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	5 20; 13 1; 20 6; 27 11
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	1 13; 8 22; 16 7; 23 16
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	6 20; 15 0; 23 4
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	2 14; 10 3; 17 16; 25 5
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	7 4; 14 22; 22 16; 30 10
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	4 10; 12 9; 20 9; 28 9
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	8 13; 17 2; 25 14
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	1 17; 11 2; 20 10; 29 18
SX Draconis	18 03.0	+ 58 23	9.3—10.5	5 04.1	11 0; 21 8
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	6 16; 13 22; 21 4; 27 10
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	4 4; 11 2; 18 0; 24 22
RZ Scuti	21.1	− 9 15	7.4— 8.3	15 03.2	15 5 30 8
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	2 17; 9 21; 17 1; 24 5
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	2 13; 9 16; 16 19; 23 22
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	2 7; 10 15; 18 22; 27 6
RR Draconis	40.8	+62 34	9.3—13	2 19.9	5 6; 13 18; 22 6; 30 18
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	4 17; 11 8; 18 0; 24 15
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	2 15; 15 12; 28 10
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	5 4; 12 20; 20 11; 28 2
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	3 20; 11 10; 19 0; 26 13
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	4 1; 11 6; 18 11; 25 15
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	3 16; 12 15; 21 14; 30 13
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	3 9; 10 3; 23 15; 30 10
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	3 2; 10 11; 17 20; 25 4
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	2 23; 8 4; 18 16; 29 4
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	5 1; 11 13; 18 2; 24 15
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	4 20; 10 20; 22 21; 28 21
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	5 5; 11 20; 18 11; 25 2
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	2 18; 11 21; 21 1; 30 5
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	3 12; 11 23; 20 9; 28 19
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	7 3; 13 22; 20 17; 27 12
UW Cygni	19.6	+42 55	10.5—10.8	3 10.8	6 20; 13 18; 20 15; 27 13
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0	5 2
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	3 2; 12 17; 22 7
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	5 17; 14 22; 24 3
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	2 4; 9 15; 17 3; 24 15
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	3 10; 11 0; 18 14; 26 5
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	6 17; 18 19; 28 22
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	6 2; 13 12; 20 20; 28 6
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	6 18; 16 10; 26 3
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	2 23; 10 20; 18 17; 26 14
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	2 16; 12 19; 22 22
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	28 4
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	3 10; 13 19; 24 4; 29 8
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	2 17; 11 0; 19 7; 27 14
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	7 16; 15 5; 22 17; 30 6
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	6 1; 14 7; 22 13; 30 19

Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1917. April							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7					30 10			
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	3 4;	11 8;	19 11;	27 14				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	6 1;	13 19;	21 13;	29 6				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	5 22		20 17					
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	2 23;	10 22;	18 20;	26 19				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	2 18;	10 13;	18 8;	26 3				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	5 19;	13 2;	20 9;	27 16				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0		10	26					
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	1 11;	10 1;	18 15;	27 5				
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	6 5;	17 8	28 12					
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	7 18;		19 9					
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	3 13;	11 5;	18 20;	26 12				
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	1 13;	11 16;	21 19					
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	5 22;	13 15;	21 8;	29 1				
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	2 8;	13 9;	24 11;	29 23				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	4 23;	12 12;	20 2;	27 16				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3		10 22						
RT Aurigae	23.0	+30 33	5.1— 6.0	3 17.5	7 12;	14 23;	22 10;	29 21				
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	7 19;	15 0;	22 5;	29 10				
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	5 20;	13 18;	21 16;	29 14				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3 10;	13 13;	23 17					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	12 06.5		20 2						
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	1 13;	9 12;	17 11	25 9				
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	1 4;	7 21;	21 6;	27 23				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	3 20;	13 2;	22 9					
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	5 12;	14 5;	22 23;					
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	6 9;	13 4;	19 23;	26 18				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	2 18;	9 8;	22 14;	29 4				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	6 13;	16 5;	25 20					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	5 13;	13 13;	21 12;	29 12				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	3 22;	10 16;	24 3;	30 20				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	5 1;	10 21;	22 12;	28 8				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	1 18;	11 3;	20 12;	29 21				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5	7 12;		24 19					
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	4 0;	12 5;	20 10;	28 15				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	3 17;	10 18;	17 18;	24 19				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	1 21;	10 2;	18 7;	26 12				
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	2 14;	8 2;	19 2;	30 1				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	2 23;	10 13;	18 2;	25 15				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	1 6;	8 16;	23 12;	30 22				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	6 19;	13 13;	20 8;	27 3				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	2 5;	8 13;	21 4;	27 12				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1		10 14;	20 8;	30 2				
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	3 20;	12 17;	21 14;	30 10				
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	5 16;	11 17;	23 20;	29 22				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	4 14;	11 14;	18 14;	25 14				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9		10 8;		27 11				
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	8 3;	15 17;	23 7;	30 21				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	4 13;	10 7;	21 20;	27 15				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	3 8;	10 2;	23 13;	30 7				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	6 5;	16 13;	26 22					
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	3 1;	9 2;	21 3;	27 4				
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	2 13;	8 16;	20 23;	27 2				
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	2 12;	8 10;	20 8;	26 6				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	1 18;	10 20;	19 22;	29 0				
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	5 6;	12 7;	19 8;	26 8				

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1916. April
	h m	° ′		d h	d h d h d h d h d h
XZ Cygni	19 30.4	+56 10	8.6— 9.3	0 11.2	4 3; 11 3; 18 3; 25 3
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	7 11; 15 10; 23 10
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	5 22; 13 14; 21 6; 28 23
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	2 20; 10 0; 17 5; 24 9
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	2 0; 10 9; 18 18; 27 3
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	5 23; 12 7; 18 15; 24 23
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	13 18; 30 4
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	4 18; 13 16; 22 12; 26 23
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	4 14; 11 7; 18 0; 24 18
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	3 1; 9 18; 23 4; 29 22
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	9 5; 23 22
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	3 7; 11 3; 19 0; 26 20
SW Aquarii	10.2	— 0 20	9.9—10.8	0 11.0	7 3; 14 0; 20 21; 27 19
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	3 8; 8 5; 17 22; 27 15
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	7 23; 16 14; 25 6
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	4 19; 10 4; 20 22; 26 6
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	7 0; 17 21; 28 18
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	3 11; 9 21; 22 17; 29 4
V Lacertae	22 44.5	+55 48	8.5— 9.5	4 23.6	2 5; 7 5; 17 4; 27 3
X Lacertae	45.0	+55 54	8.2— 8.6	5 10.7	5 0; 10 10; 21 8; 26 18
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	4 11; 9 21; 20 18; 26 5
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	5 18; 12 2; 24 16; 30 23
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	6 8; 18 11; 30 15
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.6	1 15; 11 14; 21 14; 26 13

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, January-February, 1917.

During the absence of Mr. William Tyler Olcott, Secretary of the Variable Star Association, it will be impossible to give the Notes of the Association in their usual form. Brief mention will be made of matters of interest to observers.

During the month of January the weather has given but few good nights for observing; this month's report of observations is, therefore, an unusually small one. Valuable lists of observations have been received from two new observers, Messrs. E. N. Vogelenzang and W. J. Luyten. Their lists of observations made during the past six months have been forwarded to Harvard College Observatory.

At the suggestion of Mr. Paul S. Yendell, Mr. Horace E. Ware, of Boston, Mass., has very kindly presented the Association with an Ephemeris of Algol 1917, which can be obtained by members on application to the Acting Secretary.

Mr. Allen B. Burbeck observed 213843 SS Cygni, Julian Day, 2421259.6 at 10.4 magnitude. At another observation on the same day at .95, the estimated magnitude was 8.6, a rise of over two magnitudes in a few hours. Observations of 154428 R Coronae Borealis are of particular value. The light curve of this star would indicate that minima may be expected at any time. Chi Cygni 194632, after a decided halt in the curve at magnitude 10.5 on the increasing side, is now rapidly rising, and can best be observed as a morning star.

The maximum of that most interesting irregular variable 074922 U Geminorum in January, was well observed.

VARIABLE STAR OBSERVATIONS January-February, 1917.

Jan. 0 = J. D. 2421229; Feb. 0 = 2421260; Mar. 0 = 2421288.

000843
SY Androm.

J.D.	Est.	Obs.
242		
1235.6	16.0	Bu

001046
X Androm.

1238.6	<12.0	Bu
41.6	11.9	Ba
45.6	<11.4	V
48.6	11.3	B
52.5	11.0	Nt
57.6	10.8	Ba

001620
T Ceti

1212.3	5.6	L
29.7	5.6	G
38.6	6.1	G
39.6	6.3	G
45.6	6.4	G
47.6	6.2	G
50.6	6.0	G

001726
T Androm.

1238.6	<11.8	Bu
41.6	<13.0	Ba
46.6	<12.8	Y

001755
T Cassiop.

1238.6	10.8	Bu
41.6	11.1	Ba
52.5	10.2	Nt

001838
R Androm.

1238.6	<12.1	Bu
41.6	13.5	Ba
43.6	11.8	Hu
52.6	<10.6	Wpi
52.5	12.1	Nt

001909
S Ceti

1249.5	<12.2	Ba
52.5	<12.2	Nt

002614
T Piscium

1252.5	9.2	M

003179
Y Cephei

1238.6	11.3	Bu
41.6	11.2	Ba
43.6	11.3	Hu
55.5	11.9	Ba

004047
U Cassiop.

J.D.	Est.	Obs.
242		
1238.6	<12.1	Bu
41.6	<13.0	Ba
46.6	<12.8	Y
57.6	<12.6	Ba

004132
RW Androm.

1238.6	<10.9	Bu
43.6	<13.0	Ba
59.6	<12.3	Nt

004281
RX Cephei

1218.4	7.6	Lt

004435
V Androm.

1238.6	<12.0	Bu
43.6	<13.0	Hu
43.6	<12.6	Ba

004533
RR Androm.

1238.6	<11.9	Bu
43.6	<12.8	Ba

004746
RV Cassiop.

1243.6	<12.5	Ba

004958
W Cassiop

1238.6	<11.3	Bu
43.6	12.0	Ba
46.6	12.0	Y
49.7	11.3	Me
55.5	12.0	Ba
59.5	12.2	Nt

010102
Z Ceti

1249.5	<12.8	Ba

010940
U Androm.

1235.6	11.8	Bu
35.5	11.4	D
43.6	11.7	Ba
52.5	12.0	Nt
55.5	12.0	Ba

011208
S Piscium

1238.6	<12.4	Bu
43.6	11.1	Ba
55.5	11.3	Ba

011272
S Cassiop.

J.D.	Est.	Obs.
242		
1235.6	8.6	Ba
35.6	9.2	Bu
41.6	8.8	B
42.6	8.7	B
45.5	9.0	M
49.5	9.2	Ba
52.6	8.8	B
59.5	9.2	Pi

011712
U Piscium

1238.6	10.4	Bu
43.6	11.9	Ba
52.6	12.2	Nt
52.5	<11.2	M

012350
RZ Persei

1238.6	<11.8	Bu
43.6	<13.0	Ba

012502
R Piscium

1158	7.6	Vo
61	7.7	Vo
63	7.8	Vo
65	7.8	Vo
66	8.0	Vo
68	8.0	Vo
82	7.9	Vo
84	7.9	Vo
88	7.9	Vo
90	7.9	Vo
93	8.0	Vo
1218.4	8.7	Lt
20.4	8.9	Lt
22.3	8.7	Vo
25.2	8.8	Vo
35.6	9.3	Bu
35.6	9.4	Ba
49.5	10.7	Ba
52.5	<10.3	S
52.5	11.3	M

013238
RU Androm.

1235.6	10.2	Bu
43.6	9.7	Ba
45.5	10.0	M
52.6	9.7	Nt
57.6	9.8	Ba
59.5	9.7	Nt

013338
Y Androm.

J.D.	Est.	Obs.
242		
1235.6	8.4	Bu
43.6	9.2	Ba
45.5	8.9	M
57.6	9.6	Ba
59.5	10.0	Nt

014958
X Cassiop.

1235.6	<11.6	Bu
43.6	12.3	Ba
46.6	11.6	Y
57.6	12.4	Ba
59.5	12.0	Nt

015354
U Persei

1218.4	8.2	Lt
20.5	8.3	Lt
35.6	8.2	Ba
43.6	8.0	Hu
45.5	8.4	M
45.6	8.6	V
51.6	8.5	B
55.6	9.0	Wh
55.6	8.5	Ba

015912
S Arietis

1248.6	11.0	B
49.5	11.1	Ba
52.6	11.0	Nt
57.6	11.4	Ba

021024
R Arietis

1169	<9.5	Vo
1235.6	<12	Bu
48.7	12	Me
49.5	11.4	Ba
57.6	11.1	Ba

021143
W Androm.

1243.6	12.1	Ba
55.5	11.3	Ba

021281
Z Cephei

1245.6	<11.0	V

021403
o Ceti

J.D.	Est.	Obs.
1182	3.7	Vo
84	3.7	Vo
1185	3.8	Vo
87	3.8	Vo
88	3.8	Vo
90	3.8	Vo
95	3.8	Vo
1203	3.7	Vo
03	3.8	Vo
08.3	3.9	Lt
09	3.7	Vo
09.4	3.9	Lt
11	3.7	Vo
11.3	3.9	Lt
12.2	3.8	L
12.4	3.6	L
14.3	4.2	Pe
18.2	4.1	Lt
18	3.9	Vo
19.3	3.7	L
20.3	4.1	Lt
20	3.8	Vo
22.2	4.6	Pe
22	3.9	Vo
23	3.9	Vo
24.2	4.7	Pe
25	4	Vo
26.3	4.7	Pe
26.8	4.3	Mu
27.3	4.3	Lt
27.3	4.7	Pe
27.8	4.3	Mu
29.7	4.4	G
29.3	3.9	L
35.6	4.2	Bu
35.6	4.2	Ba
36.8	4.4	G
36.2	4.8	Pe
37.7	4	Me
38.6	4.4	G
38.6	4.6	Mu
38.6	4.2	Bu
39.6	4.6	Mu
39.7	4.5	G
41.7	4.6	Mu
43.6	4.8	Ba
43.6	4.9	Mu
43.5	4.9	M
43.6	4.5	Hu
43.7	4.6	G
44.6	4.3	Me
44.6	4.8	Mu
45.6	4.7	G
45.6	4.5	Bu
45.6	4.9	Mu
46.6	4.9	Mu
47.6	4.9	Mu
47.6	4.8	G
48.7	4.8	Me
48.6	4.9	Mu
48.6	4.6	Bu

VARIABLE STAR OBSERVATIONS January–February, 1917—Continued.

o Ceti

J.D. 242	Est.	Obs
1249.7	4.8	Me
49.6	5.0	Mu
49.5	5.1	Ba
50.6	4.8	G
50.6	5.0	Mu
51.6	5.0	Mu
52.7	5	Me
52.6	5.1	Mu
53.6	5.1	Mu
53.7	4.9	G
54.6	5.1	Mu
55.6	5.1	Mu
55.5	5.3	Ba
59.6	4.7	Bu

021558
S Persei

1235.6	8.8	Ba
45.6	9.1	Hu
49.5	9.0	Ba
55.5	8.7	Ba

022000
R Ceti

1223.3	9.1	Vo
25.2	9.4	Vo
35.6	8.8	Ba
43.6	9.7	Ba
52.6	10.8	Nt

022150
RR Persei

1246.6	12.0	Y
49.6	13.0	Ba
59.6	12.8	Y

022813
U Ceti

1235.6	7.8	Ba
45.5	7.5	Ba
49.6	7.8	M
52.6	7.8	Me
57.6	7.8	Ba
59.5	9.8	Nt

023080
RR Cephei

1245.6	<11.0	V

023133
R Triang.

1203	7.3	Vo
08	7.1	Vo
09.4	7.4	Lt
11	7	Vo
18.2	7.2	Lt
18	7.2	Vo
20.4	7.2	Lt
20	7.3	Vo

R Triang.

J.D. 242	Est.	Obs.
1222	7.4	Vo
23	7.4	Vo
25.3	7.2	Lt
25	7.4	Vo
34.7	7.5	Me
35.6	7.4	Ba
35.6	7.2	Bu
43.6	8	Hu
43.7	7.7	Mu
43.7	7.7	G
45.5	7.8	M
48.6	8.1	B
49.5	8.2	Ba
50.7	8.2	Mu
52.7	8.2	Me
55.5	8.6	Ba
59.5	8.8	Pi

024356
W Persei

1235.6	8.6	Ba
43.7	9.3	G
43.7	9.3	Mu
45.6	9	Hu
49.6	9.2	Ba
50.7	9.2	Mu
55.6	10	Wh
55.5	8.8	Ba

030514
U Arietis

1241.6	12.9	Ba
55.6	12.4	Ba

031401
X Ceti

1218.4	9.7	Lt
20.4	9.8	Lt
45.6	12.3	Ba
45.6	11.5	Hu

032043
Y Persei

1235.6	8.8	Bu
35.6	8.2	Ba
45.6	8.0	Hu
48.6	9.1	M
49.6	8.2	B
55.6	8.2	Ba
59.5	9.0	Pi

032335
R Persei

1222.3	<10.0	Vo
23.4	9.9	Vo
35.6	9.2	Bu
35.6	8.9	Ba
45.6	9.3	Hu
45.6	<9.5	S
48.6	10.4	M

R Persei

J.D. 242	Est.	Obs.
1255.6	10.3	Ba
59.6	11.0	Y

033362
U Camelop.

1235.6	7.5	Ba
55.6	7.8	Ba

035915
V Eridani

1245.6	9.8	Ba
57.6	9.3	Ba

042209
R Tauri

1245.6	<10.6	Bu
45.6	<12.8	Ba

042215
W Tauri

1226.3	9.4	Pe
27.3	9.8	Pe
35.6	9.5	Ba
36.2	9.7	Pe
37.5	10.0	M
40.6	9.7	B
43.6	10.0	Ba
43.7	10.3	Mu
45.5	10.8	Wpi
45.5	10.2	Pi
45.6	10.2	Bu
45.6	9.4	Hu
45.6	10.2	Wh
49.6	10.5	Ba
50.7	10.5	Mu
52.6	10.5	Nt
53.6	9.9	B
55.6	10.8	Ba
59.6	10.6	Bu

042309
S Tauri

1245.6	<12.8	Ba
45.6	<10.6	Bu

043065
T Camelop.

1240.5	11.8	Y
45.6	11.4	Ba
57.6	10.3	Ba

043208
RX Tauri

1245.5	<11.5	Pi
45.6	<11.5	Bu
45.6	11.7	Ba
45.6	11.9	Hu
46.6	12.0	Y
57.6	<12.0	Ba
59.5	<12.0	Nt

043274
X Camelop.

J.D. 242	Est.	Obs.
1226.6	8.0	Cr
35.6	8.8	Bu
35.6	8.3	Cr
37.6	8.0	Ba
40.5	8.3	Y
45.6	8.6	V
48.6	8.3	M
50.6	8.6	B
59.5	9.0	Ba
59.5	9.4	Pi
59.6	9.1	Cr

044617
V Tauri

1240.5	12.4	B
45.6	<11.5	Bu
45.6	12.6	Ba
46.5	13	Y

045307
R Orionis

1235.6	<12.1	Bu
45.6	12.8	Ba
46.5	11.9	Y
57.6	12.0	Ba

045514
R Leporis

1195.5	7.8	Lt
1208.5	7.7	Lt
18.6	7.8	Lt
19.3	6.9	L
20.3	7.8	Lt
29.3	6.8	L
31.6	6.7	B
35.6	6.8	Ba
36.8	7.3	G
38.7	7.4	G
39.6	7.4	G
43.7	7.6	G
45.6	7.3	Bu
47.6	7.5	G
48.6	8.0	M
48.6	7.2	Bu
50.6	7.5	G
52.7	7.6	Me
52.6	7.5	B
53.7	7.6	G
57.6	6.9	Ba
57.6	8.0	Pi
59.6	8.0	Bu

050001
W Orionis

1228.7	6.1	G
29.7	6.0	G
34.7	6.9	G
36.8	6.3	G
38.7	6.1	G

W Orionis

J.D. 242	Est.	Obs.
1239.7	6.0	G
43.7	5.9	G
45.6	5.9	G
47.7	6.0	G
50.6	6.0	G

050003
V Orionis

1235.6	<12.0	Bu
45.6	<13.0	Ba
54.7	<12.1	Wh

050022
T Leporis

1228.3	8.8	L
35.6	8.2	Ba
45.5	8.7	M
45.6	9.2	Bu
57.6	8.3	Ba
57.6	8.9	Pi

050953
R Aurigae

1223.6	12.0	B
38.6	<11.8	Bu
49.6	12.5	Ba
57.6	<11.4	Pi

052034
S Aurigae

1219.3	9.6	L
28.6	9.0	Cr
31.5	8.7	B
35.6	9.2	Bu
36.6	8.3	Ba
45.6	9.0	Wh
56.7	9.4	Mu
57.5	9.8	Pi
57.6	8.8	Ba

052036
W Aurigae

1238.6	11.8	Bu
41.5	10.7	Ba
45.5	10.6	Ba
55.6	10.3	Ba
57.6	10.3	Pi

052404
S Orionis

1170.6	10.1	Lt
83.5	9.7	Lt
84.4	9.8	Lt
88.4	9.6	Lt
95.5	9.6	Lt
1203.4	9.1	Lt
08.5	8.7	Lt
18.4	8.3	Lt

VARIABLE STAR OBSERVATIONS January-February, 1917—Continued.

S Orionis.

J.D. 242	Est.	Obs.
1231.5	7.1	B
35.6	7.8	D
35.6	7.9	Bu
37.6	7.7	Ba
40.6	7.6	D
45.6	7.8	D
48.6	7.9	M
52.6	7.8	B
55.5	8.0	D
55.6	7.8	Ba
57.6	7.9	Pi
59.6	8.5	Nt

053005a

T Orionis

1219.3	10.0	L
31.6	9.9	B
35.6	10.1	Bu
35.6	10.2	D
37.6	9.9	Ba
43.7	9.4	Mu
44.6	9.9	Me
45.6	9.8	Bu
45.6	9.8	Wh
48.6	10.0	M
50.7	9.7	Mu
52.6	9.7	Nt
52.6	9.8	B
52.7	10.0	Me
55.6	10.0	Ba
57.6	10.0	Pi
59.6	10.1	Bu

053068

S Camelop

1233.6	9.2	Bu
40.5	10.2	Y
49.6	9.5	Ba
55.5	10.0	M

053531

U Aurigae

1235.6	10.7	Bu
40.5	12.0	Y
45.6	12.3	Ba

054319

SU Tauri

1226.6	10.5	Cr
27.6	10.4	Cr
28.6	10.3	Cr
35.6	9.8	Ba
36.8	10.0	E
37.6	9.7	Ba
41.5	9.8	Ba
43.6	9.8	Ba
43.6	10.0	Wh
45.5	9.9	Ba
45.5	9.9	Wpi

SU Tauri

J.D. 242	Est.	Obs.
1245.5	9.7	Pi
45.7	9.6	V
45.6	9.9	Bu
46.5	9.5	Y
48.6	9.8	Bu
49.5	9.9	Ba
51.5	9.5	B
52.5	9.5	B
52.5	9.5	V
52.6	<12.5	Nt
53.5	9.5	B
55.5	9.9	Ba
55.6	10.0	Wh
57.5	9.9	Ba
59.5	9.9	Ba
59.6	9.5	Y
57.6	9.9	Pi
59.6	9.6	Nt

054615a

Z Tauri

1246.5	±13.3	Y
59.6	<12.3	Y

054615c

RU Tauri

1246.5	13.1	Y
59.6	<12.0	Y

054920

U Orionis

1238.6	<11.6	Bu
43.7	9.5	Mu
45.6	12.5	Ba
45.6	12.3	Hu
45.7	12.3	Me
46.5	12.2	Y
55.5	11.8	M
57.6	12.2	Ba

054974

V Camelop.

1236.6	<11.5	Ba
40.5	<12.8	Y
41.5	<13.0	Ba
43.6	<13.0	Ba
45.6	<13.0	Ba
49.5	<13.0	Ba
55.5	<10.9	M
55.5	<13.0	Ba
57.5	<13.0	Ba
59.5	<12.8	Ba

055353

Z Aurigae

1238.6	11.5	Bu
40.5	9.5	Y
45.6	9.9	Ba
57.5	9.5	Pi
59.5	9.8	Ba

060124

S Leporis

J.D. 242	Est.	Obs.
1236.8	6.7	G
38.7	6.8	G
47.7	7.1	G
50.6	7.1	G
53.7	7.3	G

060450

X Aurigae

1238.6	<11.6	Bu
37.6	<12.1	Ba
45.6	<12.8	±Ba
48.6	12.7	B
52.6	9.8	Wpi
59.5	<12.8	Ba

060547

SS Aurigae

1212.3	<12.4	L
17.7	<11.6	L
19.3	<12.0	L
27.7	<12.4	L
29.3	<12.4	L
35.6	<10.8	Bu
35.6	<10.8	D
36.8	<12.6	E
37.6	<12.4	Ba
40.5	<13.3	Y
40.5	<11.8	D
41.5	<13.0	Ba
43.5	<13.0	Ba
45.6	<12.6	Bu
45.6	11.0	Hu
45.6	11.6	D
45.5	<13.0	Ba
46.5	<13.3	Y
46.6	<12.6	Bu
47.6	<11.4	V
48.6	<12.7	B
48.6	<12.4	Bu
49.5	<13.0	Ba
50.6	<12.7	B
51.6	<12.6	Bu
52.5	<11.6	V
55.6	<12.4	B
55.5	<13.0	Ba
57.5	<13.0	Ba
59.5	<12.6	Ba

061647

V Aurigae

1238.6	10.7	Bu
45.6	10.0	Ba
50.6	11.2	B

061702

V Monoc.

J.D. 242	Est.	Obs.
1243.6	8.5	Ba
45.6	8.7	Bu
48.6	8.9	M
57.6	9.4	Pi
57.6	8.8	Ba

061907

T Monoc.

1229.7	6.1	G
38.7	6.4	G
38.6	6.8	G
39.7	6.6	G
45.6	6.7	G
47.6	6.6	G
50.7	5.9	G
53.7	5.8	G

063159

U Lyncis

1240.5	12.8	Y
43.6	13.9	Ba
45.6	<11.8	Bu
55.6	13.6	Ba

063558

S Lyncis

1240.5	12.0	Y
43.6	12.4	Ba
45.6	<11.9	Bu
55.6	12.6	Ba

064030

X Gemin.

1245.6	12.2	Ba
45.6	<11.7	Bu
47.6	<11.5	V
55.6	11.0	M
59.5	11.4	Ba

065111

Y Monoc.

1243.6	10.5	Ba
45.6	9.4	Bu
57.6	10.0	Pi
59.5	9.6	Ba
62.6	9.3	Bu

065208

X Monoc.

1229.3	8.6	L
45.6	9.3	Bu
45.6	7.8	Ba
48.7	7.9	M
54.6	7.6	Hu
57.6	7.5	Pi
59.5	7.3	Ba
59.6	7.3	Bu

065355

R Lyncis

J.D. 242	Est.	Obs.
1240.5	11.2	Y
45.6	<11.7	Bu
49.6	10.4	Ba
50.6	10.6	B
59.5	10.3	Ba

070122a

R Gemin.

1223.7	8.6	Lt
27.4	9.1	Pe
45.6	9.1	Bu
45.6	9.3	Hu
47.6	9.2	B
49.6	9.0	Ba
49.6	9.4	Bu
52.6	9.6	Nt
55.6	9.7	M
55.6	9.6	B
59.5	9.7	Ba

070122b

TW Gemin.

1245.6	8.7	Bu
49.6	7.7	Ba
52.6	8.4	Nt
55.6	8.4	M
59.5	7.8	Ba

070122c

Z Gemin.

1245.6	11.9	Bu
49.6	12.5	Ba
52.6	12.4	Nt
55.6	11.9	M
59.5	<12.0	Ba

070310

R Can. Min.

1240.6	10.8	B
41.5	10.9	Ba
53.6	10.6	B
57.6	11.5	Pi
59.5	10.6	Ba

071713

V Gemin.

1245.6	10.9	Ba
47.7	<11.2	V
55.6	10.6	M
59.5	10.7	Ba

072708

S Can. Min.

1220.5	8.0	Lt
23.7	8.3	Lt
27.4	8.2	Pe
31.7	8.3	Me
40.6	8.6	D

VARIABLE STAR OBSERVATIONS January-February, 1917—Continued.

S Can. Min.

J.D. 242	Est.	Obs.
1245.6	8.6	Ba
45.6	8.7	S
45.6	8.7	D
48.7	8.7	M
50.7	8.8	Mu
52.7	9.1	Me
52.6	8.8	Wpi
53.6	8.9	B
54.6	9.0	Wh
55.6	9.4	D
55.6	8.8	M
57.6	9.4	Pi
59.5	9.5	Ba

072811
T Can. Min.

1245.6<12.5		Ba
45.6	12.3	B
53.6<12.5		B
57.6<11.8		Pi

073508
U Can. Min

1188.4	10.3	Lt
95.5	9.8	Lt
1212.4	9.6	L
17.7	9.4	L
20.5	9.6	Lt
27.7	9.5	L
45.6	9.1	Ba
45.6	10.6	Me
45.6	9.7	B
46.6	9.7	Bu
53.6	9.4	B
57.6	9.7	Pi
59.5	9.2	Ba

073723
S Gemin

1245.6	13.0	Ba
46.6	12.7	Y
55.6	12.5	C
59.6	12.7	Ba

074323
T Gemin.

1245.6<13.0		Ba
46.6	12.4	Y
59.6<12.0		Ba

074922
U Gemin.

1212.3<12.3		L
17.7<12.4		L
19.2<10.9		L
27.7<11.7		L
29.3<11.7		L
35.6<11.7		Ba
36.8<12.4		E
41.6	9.7	Cr

U Gemin.

J.D. 242	Est.	Obs.
1241.6	9.6	Ba
43.6	9.8	Wh
43.6	10.5	Ba
45.6	11.6	Bu
45.6	11.3	Ba
45.6	11.5	Wh
46.6	12.3	Y
46.6	12.0	Bu
47.6<11.7		B
47.7<11.7		V
48.6<12.3		Bu
48.6<11.7		B
48.6<13.3		Y
49.6<12.5		B
49.7<13.0		Ba
50.6<12.5		B
51.6<12.6		B
52.5<11.7		V
52.6<12.6		B
53.6<12.5		B
54.6<13.0		Hu
55.5<13.5		Ba
55.6<12.4		B
55.6<12.4		Cr
55.6<11.7		M
57.5<13.3		Ba
59.6<11.7		Cr
59.6<12.4		Y
59.5<12.8		Ba

075612
U Puppis

1245.6<12.5		Ba
46.6<13.0		Y

081112
R Cancri

1217.7	10.2	L
45.6	9.2	Ba
47.5	9.7	B
52.6	9.7	Nt
55.5	9.3	B
57.6	9.2	Ba

081617
V Cancri

1220.4	<9.3	Vo
20.5	8.7	Lt
22.3	9.3	Vo
23.7	9.0	Lt
45.6	9.6	B
45.6	8.8	Ba
48.7	9.5	M
53.6	9.4	B
59.6	9.9	Nt
59.6	9.9	Ba

081633
T Lyncis

48.7	8.8	M

082405
RT Hydrae

J.D. 242	Est.	Obs.
1249.6	7.0	Ba
49.6	7.0	B
57.7	7.4	Pi
59.6	6.9	Ba

083019
U Cancri

1246.6	13.3	Y
47.7<11.9		V
49.6<12.4		Ba

083350
X Urs. Maj.

1243.6	10.5	Ba
59.6	9.3	Ba

084803
S Hydrae

1248.7<11.5		M
49.6	12.0	B

085120
T Cancri

1217.7	9.3	L
49.6	8.0	Ba

090151
V Urs. Maj.

1212.3	10.3	L
29.3	10.2	L
43.6	10.6	Ba
45.5	10.5	Wpi
47.7	10.3	V
48.6	10.3	B
50.7	10.7	Mu
54.6	9.5	Hu
55.6	10.3	B
59.6	10.5	Ba

090425
W Cancri

1246.6<13.7		Y
49.6	12.6	Ba

093421
V Leporis

1246.6<13.0		Y

093934
R Leo. Min.

1245.6	8.2	S
48.6	8.3	Bu
49.6	8.0	Ba
52.6	7.2	Wpi
54.6	7.6	Hu
59.6	7.5	Ba
59.9	7.8	M

094211
R Leonis

J.D. 242	Est.	Obs.
1208.5	8.0	Lt
17.7	8.0	L
20.5	8.8	Lt
23.7	8.8	Lt
35.6	8.0	Ba
45.6	9.3	Wpi
46.6	9.0	Bu
48.7	8.6	B
48.6	8.8	Bu
49.6	8.5	Ba
52.6	9.8	WPi
52.7	9.5	Me
54.7	9.0	Wh
55.8	9.6	S
55.6	9.2	D
59.9	9.3	M

095421
V Leonis

1245.6<10.6		Wpi
46.6<13.0		Y
49.6<12.6		Ba

103212
U Hydrae

1195.6	5.3	Lt
1211.6	5.3	Lt
17.7	4.8	L
20.6	5.6	Lt
23.7	5.6	Lt

103769
R Urs. Maj.

1168	7.5	Vo
82	8.1	Vo
84	8.1	Vo
88	8.2	Vo
1218.4	9.2	Lt
20.3	9.2	Lt
20	8.7	Vo
26.6	9.9	Wa
35.6	10.3	Ba
40,7	10.1	D
43.6	10.6	Ba
45.5	10.0	WPi
45.6<10.5		Wa
45.6	10.5	S
46.6	10.8	Bu
48.7	10.8	B
48.7	10.5	M
55.6	11.1	B
55.6	10.8	Ba

104620
V Hydrae

1217.7	7.3	L

104814
W Leonis

1259.6	11.4	Y

110506
S Leonis

J.D. 242	Est.	Obs.
1259.6<12.0		Y

115905
RX Virginis

1229.7	8.2	L

120206
RW Virginis

1229.7	7.2	L

123160
T Urs. Maj.

1220.4	9.0	Lt
27.4	8.1	Pe
35.6	7.1	Ba
43.6	6.8	Ba
45.6	10.8	WPi
45.6	7.1	S
45.6	6.7	Wa
46.6	7.2	Bu
48.7	7.6	M
49.6	6.8	Ba
54.6	6.9	Wh
55.6	6.8	Ba
59.6<10.8		Bu

123307
R Virginis

1189.7	7.3	Lt
94.8	7.6	Lt
95.6	7.6	Lt
1201.7	7.8	Lt
20.6	9.8	Lt
23.7	10.2	Lt
27.7	10.4	L

123459
RS Urs. Maj.

1243.6<12.0		Ba
54.6<10.9		Wh
55.6<12.0		Ba

123961
S Urs. Maj.

1243.6	11.2	Ba
45.6<10.1		Wpi
45.6<10.1		Wa
46.6	10.5	Bu
48.7	10.7	M
49.6	10.9	Ba
54.6	10.4	Wh
55.8	10.1	S
55.6	10.5	Ba
59.6	9.7	Bu

124606
U Virginis

1236.8	10.2	E

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132422
R Hydrae

J.D. 242	Est.	Obs.
1229.7	9.5	L

132706
S Virginis

J.D. 242	Est.	Obs.
1217.7	8.1	L
27.7	7.4	L
29.7	6.8	L

134440
R Can. Ven.

J.D. 242	Est.	Obs.
1181.6	8.5	Lt
89.7	8.2	Lt
95.7	8.0	Lt
1201.7	8.0	Lt
20.5	8.0	Lt
23.7	8.0	Lt
29.7	8.3	L
36.8	8.7	E
55.8	8.7	S
59.9	9.0	M

141567
U Urs. Min.

J.D. 242	Est.	Obs.
1174.4	8.7	Lt
85.4	8.4	Lt
88.4	8.4	Lt
95.4	8.4	Lt
1220.5	8.8	Lt
23.7	8.9	Lt
37.5	8.9	Ba
45.6	8.8	S
49.6	9.1	Ba
52.6	9.1	Wpi
59.6	9.9	Ba

142539
V Bootis

J.D. 242	Est.	Obs.
17.7	10.2	L

142584
R Camelop.

J.D. 242	Est.	Obs.
1237.6	9.4	Ba
49.6	9.4	Ba
49.6	9.2	B
52.6	9.4	Wh
57.5	8.8	Ba

143227
R Bootis

J.D. 242	Est.	Obs.
1217.7	9.2	L

153378
S Urs. Min.

J.D. 242	Est.	Obs.
1212.4	10.6	L
37.5	9.6	Ba
49.6	9.5	B
52.6	<10.8	Wpi
52.6	9.2	Wh
59.6	6.6	Ba

154428
R Cor. Bor.

J.D. 242	Est.	Obs.
1223.8	6.2	Lt
27.7	6.0	Lt
29.7	6.0	L
59.10	5.8	M

154539
V Cor. Bor.

J.D. 242	Est.	Obs.
1259.10	8.7	M

162542
g Herculis

J.D. 242	Est.	Obs.
1208.2	5.3	Lt
22.2	5.5	Lt
25.8	5.4	Lt

162807
SS Herculis

J.D. 242	Est.	Obs.
1227.7	<11.5	L

163137
W Herculis

J.D. 242	Est.	Obs.
1259.10	8.8	M

163172
R Urs. Min.

J.D. 242	Est.	Obs.
1237.5	9.5	Ba
59.9	9.4	M
59.6	9.3	Ba

163266
R Draconis

J.D. 242	Est.	Obs.
1209.3	8.1	Lt
20.5	8.0	Lt
23.7	8.2	Lt
26.6	8.0	Cr
37.5	8.3	Ba
55.5	9.7	S
59.9	9.7	M
59.6	10.3	Ba

164055
S Draconis

J.D. 242	Est.	Obs.
1259.9	8.7	M

184205
R Scuti

J.D. 242	Est.	Obs.
1195.2	6.0	Lt
1203.2	6.3	Lt
03.2	5.5	Vo
08.2	6.1	Lt
08.2	5.5	Vo
11.2	6.1	Lt
12.2	6.0	L
19.2	5.9	L
22.2	6.1	Lt

185243
R Lyrae

J.D. 242	Est.	Obs.
1208.2	4.2	Lt
18.2	4.1	Lt
20.3	4.1	Lt
22.2	4.2	Lt
23.7	4.2	Lt
25.3	4.2	Lt

192743
AF Cygni

J.D. 242	Est.	Obs.
1209.3	7.6	Lt
18.3	7.3	Lt
22.3	7.0	Lt
23.7	6.8	Lt
25.3	6.8	Lt

193732
TT Cygni

J.D. 242	Est.	Obs.
1237.6	7.3	Ba

194048
RT Cygni

J.D. 242	Est.	Obs.
1209.3	8.1	Lt
22.3	8.7	Lt
23.7	8.8	Lt
25.3	8.9	Lt
37.5	9.4	Ba
55.5	<9.3	S

194632
χ Cygni

J.D. 242	Est.	Obs.
1218.3	8.4	Vo
19.2	10.5	L
20.4	8.7	Vo
22.2	8.7	Vo
31.2	9.8	Pe
36.2	<9.6	Pe
40.5	9.6	Y
43.5	8.5	M

200647
SV Cygni

J.D. 242	Est.	Obs.
1237.5	8.1	Ba
49.5	8.6	Ba
50.6	9.0	Mu

200715a
S Aquilae

J.D. 242	Est.	Obs.
1213.2	10.5	L

200747
RX Cygni

J.D. 242	Est.	Obs.
1250.6	7.8	Mu

200938
RS Cygni

J.D. 242	Est.	Obs.
1222.3	9.0	Lt
L	29.3	8.4
L	37.5	7.3
Ba	49.5	7.4
Ba		

201521
RT Capricorni

J.D. 242	Est.	Obs.
1213.2	7.1	L

201647
U Cygni

J.D. 242	Est.	Obs.
1166.4	10.4	Lt
68.3	10.3	Lt
82.4	9.6	Lt
94.5	9.6	Lt
85.3	9.6	Lt
90.3	9.6	Lt
95.4	9.5	Lt
1220.4	9.2	Lt
22.3	9.2	Lt
23.3	9.2	Lt
25.3	9.1	Lt
26.5	8.0	Cr
35.5	7.7	Cr
37,5	7.8	M
49.5	7.4	Ba
55.5	8.0	S
55.5	7.4	Cr
56.4	7.4	Wh
57.5	7.8	Pi

202539
RW Cygni

J.D. 242	Est.	Obs.
1212.3	9.1	L
37.5	8.6	Ba
37.5	8.4	M
49.5	8.9	Ba
56.4	8.9	Wh

202946
SZ Cygni

J.D. 242	Est.	Obs.
1212.3	9.7	L
13.2	9.5	L
29.3	9.8	L
35.6	9.3	Ba
36.5	9.4	Ba
37.5	9.5	Ba
41.5	10.0	Ba
49.5	9.3	Ba
55.5	9.9	Ba
56.4	9.6	Wh
59.5	9.5	Ba

203816
S Delphini

J.D. 242	Est.	Obs.
1240.5	9.0	Y

203847
V Cygni

J.D. 242	Est.	Obs.
1252.5	10.3	M

204016
T Delphini

J.D. 242	Est.	Obs.
1240.5	<12.5	Y

204017
U Delphini

J.D. 242	Est.	Obs.
1218.2	6.8	Lt
22.3	6.6	Lt
25.3	6.5	Lt

204318
V Delphini

J.D. 242	Est.	Obs.
1240.5	<12.7	Y

204405
T Aquarii

J.D. 242	Est.	Obs.
1185.3	7.9	Lt
88.3	8.0	Lt
95.3	8.0	Lt
1222.3	9.0	Lt

204846
RZ Cygni

J.D. 242	Est.	Obs.
1240.5	10.8	Y

205923
R Vulpeculae

J.D. 242	Est.	Obs.
1237.5	8.8	M

210129
TW Cygni

J.D. 242	Est.	Obs.
1240.5	<12.5	Y

210868
T Cephei

J.D. 242	Est.	Obs.
1178	7.7	Vo
82	7.6	Vo
84	7.5	Vo
88	7.5	Vo
90	7.5	Vo
94	7.4	Vo
95	7.4	Vo
1203	6.8	Vo
03.2	6.9	Lt
08	6.8	Vo
08.5	6.8	Lt
11	6.6	Vo
11.3	6.7	Lt
12.3	6.0	L
17.2	6.6	Vo
18.2	6.4	Lt
18.3	6.6	Vo
20.4	6.4	Vo
22.3	6.4	Lt
22.2	6.4	Vo
23.3	6.5	Lt
23.2	6.4	Vo
25.3	6.4	Lt
25	6.4	Vo
29.6	5.3	G
36.8	5.1	G
37.6	5.7	Ba
38.7	5.1	G
39.6	5.2	G

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T Cephei

J.D. 242	Est.	Obs.
1243.7	5.1	G
50.6	5.2	G
53.7	5.2	G

213244
W Cygni

1206.3	6.6	Vo
08.2	6.5	Lt
09.4	6.5	Lt
12.3	5.7	L
13.2	6.0	L
14.3	6.1	Pe
16.3	6.7	Vo
18.3	6.6	Lt
19.2	5.8	L
20.3	6.5	Lt
22.3	6.6	Lt
23.3	6.6	Lt
25.3	6.6	Lt
28.2	6.7	Vo
29.7	5.7	G
29.3	5.8	L
38.7	5.9	G
39.7	6.0	G

213678
S Cephei

1252.6	<10.2	S

213753
RU Cygni

1237.5	8.0	M

213843
SS Cygni

1212.3	11.8	L
13.2	11.8	L
19.2	11.7	L
26.5	10.3	Cr
27.5	11.0	Cr
29.3	11.5	L
30.5	11.1	Cr
31.5	11.4	B
35.6	11.8	Ba
35.5	<11.2	Cr
35.5	<10.2	D

SS Cygni

J.D. 242	Est.	Obs.
1235.6	11.6	Bu
36.5	11.8	Ba
37.5	11.8	Ba
40.5	11.8	B
40.5	11.5	Y
40.5	11.7	D
41.5	11.5	B
41.5	11.7	Ba
41.5	<11.7	D
42.5	11.6	B
43.5	12.0	M
43.5	11.8	Ba
45.5	12.0	Pi
45.6	11.6	Bu
45.5	11.1	V
45.5	11.4	D
45.5	11.8	Ba
46.6	11.8	Bu
48.5	12.0	B
48.6	11.9	Bu
49.5	11.8	Ba
49.5	11.9	B
50.6	11.1	Mu
50.5	11.9	B
51.6	11.8	Bu
51.5	11.9	B
52.5	11.8	B
52.5	<11.3	V
52.5	<9.6	S
52.5	11.6	Nt
53.5	11.6	B
55.6	<11.7	Bu
55.5	<11.0	D
55.5	<11.3	Pi
55.5	<11.6	B
55.5	11.9	Cr
55.5	<9.6	S
55.5	11.8	Ba
56.6	<11.3	Bu
57.5	<10.1	Pi
57.5	<11.3	Ba
58.5	10.6	D
59.5	10.6	Cr
59.5	10.5	Pi
59.5	10.0	Nt

SS Cygni

J.D. 242	Est.	Obs.
1259.5	<10.7	Ba
59.5	10.0	Bu
59.6	10.4	Bu
59.95	8.6	Bu
62.6	8.7	Bu

213937
RV Cygni

1237.6	6.8	Ba
37.5	7.5	M
45.5	8.9	Pi

214058
μ Cephei

1229.7	3.4	G
36.8	3.4	G
45.6	3.4	G
47.7	3.3	G
50.7	3.4	G
53.7	3.5	G

215934
RT Pegasi

1245.5	10.0	V

222439
S Lacertae

1240.5	8.7	Y
49.5	8.1	Ba
49.6	8.0	B

222557
δ Cephei

1229.8	4.1	G
36.8	4.0	G
45.6	4.0	G
47.7	3.9	G
50.7	4.0	G
53.7	3.8	G

223841
R Lacertae

1240.5	12.8	Y

230110
R Pegasi

J.D. 242	Est.	Obs.
1168.4	10.7	Lt
85.3	10.1	Lt
95.3	9.6	Lt
1208.3	9.1	Lt
20.3	8.5	Lt
22.3	8.4	Lt
23.3	8.4	Lt
25.2	8.5	Lt
36.2	9.2	Pe
36.5	8.4	Ba
43.6	9.0	Mu
45.6	8.6	Me
49.5	9.1	Ba
50.6	8.9	Mu

230759
V Cassiop.

1226.4	9.3	Pe
27.4	9.4	Pe
36.5	8.4	Ba
41.6	8.3	B
43.6	7.9	Hu
45.6	8.4	Wa
49.5	7.8	Ba
52.6	7.9	B
59.5	8	Pi

231425
W Pegasi

1245.5	<11.0	V

233335
ST Androm.

1237.6	9.3	Ba
42.5	10.2	B
43.6	9.0	Hu
49.5	9.7	Ba
52.5	10.4	Wpi
52.5	10.2	Pi
52.6	10.1	S
53.6	10.0	B

233815
R Aquarii

J.D. 242	Est.	Obs.
1187.3	7.9	Lt
88.4	7.9	Lt
90.3	8.0	Lt
95.3	8.0	Lt
1208.2	8.4	Lt
19.2	8.9	L

233956
Z Cassiop.

1249.5	<12.0	Ba

235209
V Ceti

1218.4	6.5	Lt

235350
R Cassiop.

1182.3	11.0	Lt
85.5	10.9	Lt
88.4	10.7	Lt
95.5	10.3	Lt
1208.5	9.8	Lt
18.3	9.3	Lt
20.3	9.0	Lt
22.3	8.5	Lt
23.3	8.4	Lt
25.2	8.0	Lt
36.7	6.8	Ba
40.6	6.4	B
43.6	7.0	Hu
45.6	7.0	Hu
49.5	6.2	Ba
52.6	6.4	B
55.6	6.6	M

235525
Z Pegasi

1236.5	9.6	Ba
45.6	10.1	V
49.5	9.9	Ba

235939
SV Androm.

1243.6	<12.6	Hu
46.5	<13.1	Y
59.5	12.5	Ba

The manner in which members of the Association have responded to the request to mail their reports, so they shall be received on the first of the month, has been of such great assistance in making up this report that the acting secretary wishes to express his thanks.

The following members contributed to this report: Messrs. Bancroft, Bouton, Burbeck, Ducharme, Crane, Eaton, Gray, Hunter, Lacchini, Luyten, McAteer, Meeker, Mundt, Nolte, de Perrot, D. B. Pickering, S. W. Pickering, Vrooman, Vogelenzang, Waterhouse, Whitehorn, Miss Swartz, and Miss Young.

The following table gives calculated dates of Maxima taken from the "Companion to the Observatory", and dates predicted by Mr. Leon Campbell, published in Harvard College Observatory, Circular 197:

CALCULATED DATES OF MAXIMA.

From the Companion to the Observatory	Dates of maxima predicted by Mr. Leon Campbell		
Mar. 1	Jan. 11	235350	R Cassiopeiæ
3	Mar. 16	181136	W Lyræ
7	Apr. 11	142539	V Boötis
12	May 1	201647	U Cygni
12	No max.	011272	S Cassiopeiæ
13	Feb. 17	123160	T Urs. Maj.
14	Mar. 16	194632	Chi Cygni
15	Mar. 22	030514	U Arietis
22	Jan. 26	230759	V Cassiopeiæ
22	July 24	090425	W Cancri
24	Jan. 31	*121418*	R Corvi
27	Apr. 11	153378	S Urs. Min.

JOHN J. CRANE,
Acting Secretary.

SU Persei.—On a recent visit to this Observatory, Dr. J. van der Bilt, of the University Observatory, Utrecht, Holland, stated that in the course of a series of observations on SU Persei one of the comparison stars, B. D. +56° 547, had frequently shown fluctuations in brightness, and requested that a number of photographs might be placed at his disposal by means of which he could confirm this variation. In an examination of 135 plates, comparisons with two adjacent stars showed a variation amounting to nearly a magnitude. Since, however, the suspected variable is of Type K5, and gave images which were often found to be more hazy than those of the comparison stars, both of which are white stars, Miss H. S. Leavitt, of this Observatory, undertook more accurate measurements. Using 4 white and 2 red comparison stars, she measured 14 plates on which Dr. van der Bilt had found the star bright, and 14 others on which he had found it faint. The white comparison stars gave a variation between 9.9 and 10.6 (0.7 magn.), while the red stars gave the limits 9.8 and 10.4 (0.6 magn.). The variability of the star therefore seems to be established.

From measurements on 4 plates, Miss Leavitt found the mean photovisual magnitude to be 7.94, while the mean photographic magnitude was found to be 10.02. This gives a color index of 2.08 magn., in accordance with that suggested by the data given by van Maanen in "Recherches Astronomiques de l'Observatoire d'Utrecht" V, p. 41.

No details concerning the light elements have yet been derived.

Harvard College Observatory, Bulletin 625. EDWARD C. PICKERING.
Cambridge, Mass., U. S. A., January 24, 1917.

COMET AND ASTEROID NOTES.

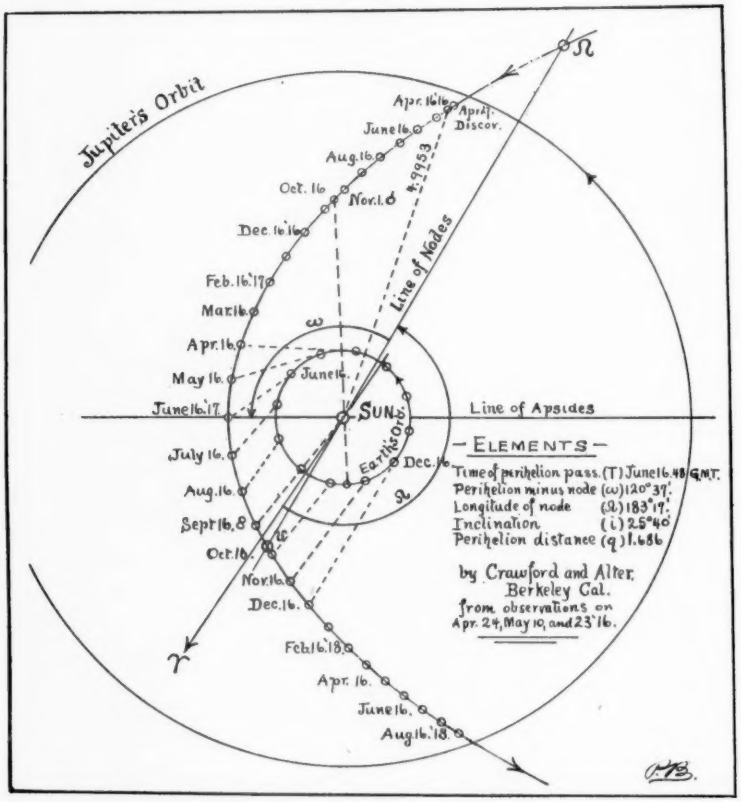

DIAGRAM OF THE ORBIT OF COMET *b* 1916 (WOLF).

Comet *b* 1916 (Wolf).—This comet is now in the tail of Serpens, near the equator, between Ophiuchus and Aquila, and is moving slowly eastward. Its calculated brightness is sixteen times that at discovery and increasing rapidly. We are sorry not to be able to publish an ephemeris for this month, but none has come to hand. The latest ephemeris is published in the January number of POPULAR ASTRONOMY.

Mr. Paul Biefield, director of the Swasey Observatory of Denison University, Granville, O., has sent us the accompanying diagram of the comet's path with reference to those of the Earth and Jupiter. From this it may be seen that the comet will be nearest the earth in July. It should be a splendid telescopic object all summer and may be visible to the naked eye at its best.

COMMUNICATIONS.

A Bright Meteor.—On the evening of Monday, Feb. 5, 1917, at about 8^h 20^m 30^s C. S. T. I saw a very bright meteor. If anyone else saw the same one and can give me its apparent path, I should like to hear from him, either directly or through the columns of POPULAR ASTRONOMY, so that I can compute its real path in space.

As seen from Iowa City the meteor first appeared in altitude 20°, azimuth 80° E. of N., and falling straight down, vanished in altitude 5°. All these figures are only approximate, of course. Though there was a full moon in the sky, the meteor appeared as bright as one of the bright stars shot from rockets, and I am sure that on a dark night it would have lit up the country in a similar manner. It moved slowly, occupying perhaps 3 seconds in its fall. O. H. TRUMAN.

State University of Iowa, Iowa City, Ia.
February 6, 1917.

A Brilliant Meteor.—I would like to report that on January 18 at 7^h 41^m I saw an extraordinary meteor of unusual size and brilliancy, the brightest one I have ever seen. It appeared near ν Piscium and after having traversed 25° of space, disappeared 3° south of ω Piscium. The duration was 4 seconds. I should estimate it at a height of about 50 miles from the Earth. It was travelling slowly and left no trail. W. P. MEEKER.

Miami, Florida, Jan. 19, 1917.

A Class for Amateurs.—In a recent communication to POPULAR ASTRONOMY, the wish is expressed for a class for amateurs.

May I say that for two years now, systematic efforts have been made by the Society for Practical Astronomy to meet that very need. In the spring of 1915, steps were taken to organize a new section in the society, devoted to the practical teaching of elementary astronomy, and one of its main objects is to give instruction by correspondence; not a reading course, but one based on the laboratory method, with the heavens and their phenomena as direct objects of study.

During the past year, the enrollment in this course has included a school girl, a gardener eighty years old, high school teacher, one in an institution for the deaf, business man, and college teacher.

Inquiries about details are welcomed. MARY E. BYRD.
Director of Section, in S. P. A., for the Practical Teaching of Astronomy.
Route 9. Box 77, Lawrence, Kansas.

Driving Clock for a Small Telescope.—The attention of the one who was asking for information in the February number is called to the article by Professor Wm. F. Rigge in POPULAR ASTRONOMY, Vol. XX, p. 551, November 1912.

GENERAL NOTES.

Mr. J. A. Hardcastle has been appointed to succeed Dr. Dreyer as director of the Armagh Observatory (Ireland). Mr. Hardcastle, who is well-known as a University Extension Lecturer on Astronomy, is a vice-president of the British Astronomical Association, and has served on the Council of the Royal Astronomical Society. He is a grandson of Sir John Herschel. (*The Observatory*, January 1917.)

Astronomy in Canada.—This is the title of the President's Address, by Albert D. Watson, at the annual meeting of the Royal Astronomical Society of Canada, on January 23, 1917. It is published in *The Journal* of that Society for February, 1917. It gives a brief account of the work of each man who has contributed to the advancement of astronomy in Canada during the past half century, and is illustrated with 31 individual portraits and one group of six.

Sunset Phenomena and the War.—In the *Journal of the Royal Astronomical Society* for February Mr. A. F. Hunter expresses the conviction that the rich color of the sunset sky in our latitude has been augmented by the dust and vapors resulting from the bombardments in Europe. He says:

"The persistence of the richer color this autumn has turned my suspicions as to the cause into firm belief. From the Suez Canal to the Gulf of Riga is 30 degrees of latitude, filled more or less continuously with millions of bursting shells, thousands of battleships and transports running to and fro by sea, and thousands of motor vehicles by land. No volcanic eruption ever equalled this output of smoke and dust. Knowing as we do the great distance to which this may be carried in the drift of the higher atmosphere from west to east in the northerly latitudes, can anyone doubt the cause of our intenser sunsets?"

The Thickness of the Atmosphere of Jupiter.—In the *Journal* of the British Astronomical Association for November 1916 Mr. Edwin Holmes criticises the following statement of another member of that Association:

"A planet in such a condition" (as Jupiter) "must *necessarily* have a dense and deep atmosphere."

After referring to an investigation by Mr. E. W. Maunder of the circumstances which settle the heights of planetary atmospheres, Mr. Holmes says: "We must not forget that on Jupiter gravity doubles the pressure (or halves it) every 1.6 miles. M. Flammarion calculated that if his atmosphere had a depth of only 100 kilometers, or about 63 miles, the density at 37 miles from the surface would be the density of platinum, 'and yet there are 25 more doublings of density in the remaining descent.' He adds: 'It is perfectly monstrous.' The atmosphere at the surface would be 17 millions of times more dense than platinum. I think this amounts to telling us that long before we reached even 37 miles down, the atmosphere would be compressed into a solid body and would be in no reasonable sense an atmosphere at all. And the clouds in any case under these conditions must be extremely thin, and Jupiter's beauty only skin deep."

Harvard College Observatory.—Parts 4, 5, 6, 7, and 8 of Volume 80 of the Annals of Harvard College Observatory have just come to hand. The subjects are as follows:—

No. 4. The Northern Milky Way. By Solon I. Bailey.
No. 5. Systematic Photographic Tests, 1911-1915. By Edward S. King.
No. 6. Comparison of Stellar Images. By Edward S. King.
No. 7. Scale of the Cordoba Durchmusterung. Zones —52° to —61°.
No. 8. The Light Curve of T Andromedae. By H. C. Wilson.

In No. 4 Professor Bailey gives a series of nine photographs of the Northern Milky Way corresponding to the nine photographs of the southern Milky Way which were published in the Harvard Annals, Volume 72, No. 3. The photographs were taken with a Cooke lens of about one and a half inches aperture, having a focal length of thirteen inches. The exposures in each case extended through several nights, the mean exposure of the southern plates being $16^h\ 4^m$, and of the northern, $22^h\ 22^m$. The plates are 8x10 inches and oriented so that the long way of the plate is perpendicular to the median line of the Milky Way. Each plate covers an area of the sky about 32° x 40°. The two sets of plates, 18 in all, when placed side by side in order of Galactic longitude, form a very complete and splendid picture of the entire Milky Way, taken with the same instrument and with approximately equal exposure. The ramifications of the details in the structure of the clouds, both light and dark, in the Milky Way are very wonderful.

In No. 5 Mr. King gives the results of tests of the photographic plates used in the regular work of the Observatory during the years 1911-1915. He finds a satisfactory uniformity in the sensitiveness of the plates, in the sources of light used in the tests, and in the working of the developers used in the photographic work. Plates do not increase in sensitiveness with age, but rather suffer a decrease amounting to about 0.01 magnitude per month for six months, after which time the decrease is more rapid.

In No. 6 Mr. King gives photographic reproductions of the images of stars formed by various telescopes which have been much used in celestial photography in recent years.

In No. 8 Professor Wilson gives a study of the Light Curve of the variable star T Andromedae based upon several hundred of the Harvard photographs and various published visual observations, extending over the period 1891-1916. The light variations, although not perfectly regular, are much more so than those of most long period variables. Twenty-eight maxima are fairly well satisfied by the following elements:

$$\text{Maximum} = \text{J. D. } 2416567 + 281.25^d\ E + 24^d \sin 11°.25\ E.$$

The brightness of the star visually is from 8.1 to 8.9 at maximum and from 13.2 to 14.2 at minimum. The photographic range is from 9.5 to 10.2 at maximum and 13.9 to 15.2 at minimum.

The Nebula N. G. C. 2261.—A spectrogram of Hubble's variable nebula N. G. C. 2261, which has as its nucleus the variable star R Monocerotis, shows the nucleus and the nebula to have the same peculiar spectrum, consisting of bright lines or bands—not those typical of gaseous nebulae—and a continuous spectrum. This observation suggests that the nebula shines by reflected light of the pulsating nucleus, and that the flow of the light-pulses over the nebula causes its variation and could give its distance.

A statement by Mr. Lampland from an examination of his direct photographs is given herewith:

Two exposures on this nebula with the 40-inch reflector made March 2, 1916,

and January 25, 1917, shows striking differences in parts of the nebulous detail. The magnitude of the apparent changes might suggest as a possible explanation that we are not witnessing the actual transference of matter, but the progressive motion or outward flow of a wave or pulse of light of greatly increased intensity, resulting from the fluctuation in the brightness of the variable star in the apex of the comet-shaped nebulosity. Sufficiently marked variations above or below the more normal light might thus become visible as relatively bright masses or dark lanes, the observed form and rate of motion of which would depend upon the distribution in space of the matter illuminated. It is hoped that additional observational material may give more definite information on the nature and magnitude of the changes taking place. From the material now available it is difficult to give any trustworthy value for the apparent displacement. It may be as great as fifteen seconds of arc. Taking this value and the simplest case of displacement perpendicular to the line of sight, which would give a maximum value for the distance and would generally overstate it, the parallax would be about 0″.00027 or the distance 12000 light years.

V. M. SLIPHER,
Director.

Lowell Observatory, Observation Circular,
Flagstaff, Arizona, January 29, 1917.

The Work of Harvard College Observatory.—The following extract from the annual Report of the Committee to visit the Observatory and the Department of Astronomy is interesting as giving a brief summary of the work of one of the most famous observatories in the world. The four great lines of investigation which have been persistently held to and developed to a greater success and extent than elsewhere under Professor Pickering's direction are summed up as follows:

(1) The classification of 228,000 stars according to their type of spectra.

(2) Measures exceeding two million in number of the visual brightness of the stars.

(3) The Study of Variable Stars; three-fourths of all the known ones having been discovered at Harvard.

(4) The Determination of the photographic magnitudes of the stars. This last investigation is being actively pushed at the present time in spite of many inherent difficulties.

By international consent the Classification of Stellar Spectra and the Scale of Magnitudes which were worked out at Cambridge have been adopted as the standard of the world.

That the Observatory is the authority on spectral classification is shown by the fact, that even in advance of the publication of the New Draper Catalogue, application for its results in the case of several thousand stars has been made by the astronomers of Denmark, England, France, Germany, Holland, and Italy, as well as by many observers in the United States.

Though the answers to these requests have entailed much time and effort, they have been furnished in advance of publication, as Professor Pickering believes that all personal and local considerations should be secondary to the advancement of science.

The first image of a star ever made on a photographic plate was taken by Professor G. P. Bond in 1851. The development of photographic astronomy since that date has been little short of marvellous.

In this work Harvard has taken a most important part. During the last quarter of a century the history of the entire sky has been permanently preserved by photography. Through all these years a "sky patrol" has been kept without interruption, the station at Arequipa, Peru, supplementing the work at Cambridge.

We thus have a complete history of the stars down to the eleventh magnitude during the past twenty-five years, written by the stars themselves on a quarter of a million plates. This history is duplicated nowhere on earth. The weight of the glass of these photographs is one hundred and twenty tons.

It hardly needs to be stated that this rich mass of material has never been adequately studied, but on that account it is not less valuable, for like all other historical records it grows more important with the passing years.

The great success of the administration of the Observatory in the eyes of the astronomical world is evidenced by the recognition which its staff has received from foreign societies.

Awards to Astronomers by the French Academy of Sciences.—Among the prizes awarded at the meeting of the French Academy of Sciences at Paris, on December 18, 1916, the following are of special interest to astronomers:

The Lalande Prize was awarded to M. Jérome-Eugéne Coggia, who has been connected with the observatory at Marseilles for the past sixty years. The award was made for the whole of M. Coggia's work and was increased from the usual amount to one thousand francs.

The Valz Prize was awarded to M. Giovanni Boccardi, director of the new Turin observatory for his researches on the variation of latitude and his discovery of a sensible inequality in the semi-lunar period.

The Gold Medal of the Janssen Prize was awarded to M. Charles Fabry, and a silver-gilt medal to M. Henri Buisson and to M. Henry Bourget, his collaborators at the Marseilles Observatory in determining the temperature of the Great Nebula in *Orion*, and the atomic weight of the unknown gas within the nebula whose presence is shown by spectrographic observations. A footnote states that M. Fabry's medal was really struck off in silver-gilt like the two others, but bears the name "gold-medal" and is accompanied by an award of three hundred francs.

The sum of two thousand francs from the Fonds Bonaparte was awarded to Pere Joseph Laïs, astronomer in charge of the Carte du Ciel at the Vatican Observatory, to assist him in carrying on this work.

(Publications of the Astronomical Society of the Pacific, February, 1917.)

New Telescope for Cordoba Observatory.—The National Astronomic Observatory at Cordoba, Argentina, the staff of which includes an American director and other members, will soon possess a new telescope, which, it is claimed, will be the most powerful in the Southern Hemisphere and the third most powerful in the world.

The Argentine Congress appropriated, in 1912, 280,000 paper pesos ($118,888) for the telescope and its dome. It will be situated 1,200 meters (3,937 feet) above sea level in the Sierra Chica, and a special road has been built to the site. The parts of the dome, except the thin steel sheathing, were completed and received in Argentina in 1914. They were purchased from a firm in Cleveland, Ohio, which is also building the mounting, contracted for in 1914. The dome is of steel and 18 meters (59 feet) in diameter.

The telescope, which is a reflector, will have an aperture of 61 inches. The great mirror, together with the auxiliary mirrors and those for testing, is being ground and figured in optical shops attached to the Cordoba Observatory expressly for the purpose. The testing mirrors, including a 30-inch spherical, a 36-inch flat, and several smaller ones, have been completed. The great mirror has been ground and polished on the back, the edge is ground and grooved, and it is now ready for turning over and work on the face. The discs of glass for all of the mirrors were obtained from France just before the war. The large disc was 10 inches thick and, crude, weighed 2,315 pounds.

The telescope will be used almost entirely for photographic observations, both

direct of the structure and positions of nebulæ and stars, and for photographing the spectra of stars, etc. It will also be used to a less extent for general observations including photometry. (*Commerce Reports*. Consul WILLIAM DAWSON, JR., Rosario, Argentina, January 10, 1917.)

Space, Time and Gravitation.*—The interesting theory of relativity continues to fill a good deal of space in contemporary physical research. A brief outline of the theory was given in this *Publication*, Vol. 23, 219, but the theory as originally put forward by Einstein has been subjected to so many alterations as now to be referred to as the "old" theory of relativity. In its present form all laws of nature must be invariant for *any* transformation of coördinates, instead of for one particular class of transformations as in the earlier Einstein theory. "Gravitation is thus put on quite a different footing from all other forces of nature—it is no longer a 'force', properly speaking—it is more of the nature of a property of the four-dimensional time-space, imparted to it by matter or energy located in it." In place of our ordinary three-dimensional Euclidean space, we have now postulated a four-dimensional time-space, where time is the fourth parameter. The mathematics of such a physical universe is somewhat complicated, but it seems to fit well with all observed phenomena. Of the more important astronomical bearings of the theory three points may be mentioned. There should theoretically be a minute deflection of a ray of light passing through a strong gravitational field, and stars in the neighborhood of the eclipsed Sun should show a slight apparent increase of distance from the Sun's center. This is perhaps the only direct physical observation which can be made to test the theory; plans had been made to test this point during the total eclipse in Russia in 1914, but no results were secured because of clouds. The spectrum lines from the Sun or massive stars should also show a displacement toward the red; in the case of the Sun it would amount to about 0.6 A, and it has been suggested, though doubtless without foundation, that the so-called K-term in the solutions for the solar motion might be due to this cause. There are such shifts in solar lines, but not the same for all lines, and probably due to other causes. Finally, the theory removes the outstanding discrepancy in the motion of *Mercury*.

Many will feel that the idea of a four-dimensional time-space is fully as difficult of comprehension as was the mystery of gravitation, all-pervading, inexplicable, in our classical physical theories. While the mathematician is willing to admit that many other forms of space or geometries of space would satisfy physical science as well as the Euclidean, we must confess that we are still at the point of view of the mathematician who stated that, while it would be impossible, in a four-dimensional universe, to turn an egg inside out without breaking its shell, still he realized that there were many practical difficulties in the way of the accomplishment of this feat.

To this extent one may sympathize somewhat with Professor See's point of view. However, the impressive quantities which he quotes as examples of the mighty force of gravitation, though often used in this connection are apt to be misleading. An equation of the form $\infty.0 = x$ may have almost any value for its second member; only when we deal with the almost infinite masses of astronomy

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* On Einstein's Theory of Gravitation, and its Astronomical Consequences. W. de Sitter, *Monthly Notices*, 699, 1916.

Space, Time, and Gravitation, by W. de Sitter. *The Observatory*, October, 1916.

Einstein's Theory of Gravitation. T. J. J. See, *ibid*, December, 1916.

will x be very great, for the fact remains that gravitation is so minute, so infinitesimal in comparison with the ordinary forces with which the physicist deals, that it may well be regarded as zero in comparison with them. Given two masses of matter, one composed entirely of positive, and the other of negative electrons, we can calculate the electrostatic attraction between these masses, itself not an unduly powerful force, but one with which the physicist has frequently to deal. Calculating now in like manner the gravitational attraction between the same two masses, how much smaller is the gravitational than the electrostatic attraction? It is smaller in the ratio of unity to 10^{41}! In words, gravitation is one hundred thousand billion billion billion billion times the smaller.

In its unification of all matter and all forces in a single simple and homogeneous system the theory of relativity is certainly an attractive one, to say the least. Though it, too, may eventually pass into the limbo of discarded physical theories, its future development and possible applications will be followed with great interest.

H. D. CURTIS.

(Publications of the Astronomical Society of the Pacific, February, 1917.)

An Introduction to Astronomy, by Forest Ray Moulton, Ph. D., Professor of Astronomy in the University of Chicago, Research Associate of the Carnegie Institution of Washington. New and revised edition. xxii + 577 pages. The Macmillan Company, 66 Fifth Avenue, New York. Price $2.25.

Those teachers who have been using Moulton's earlier book with the same title will welcome this new edition. It is not merely a revision of the first edition, bringing the various paragraphs up to date, but the entire book has been rewritten and some important modifications have been made. The subject of the Reference Points and Lines has been deferred until Chapter IV and the consideration of the Earth and its motions taken up in Chapters II aud III. The study of the Constellations unfortunately is left until Chapter V, which will not be reached by the ordinary college class until the weather is too cold for out-door study. This study ought to be begun in the first weeks of the college year. The instructor, however, can easily take this up out of the text-book order.

Most of the chapters have been enlarged, especially the last, on the Sidereal Universe, the numerous discoveries made during the last ten years, rendering this imperative.

Nearly all of the illustrations are new, a large number of them coming from the splendid photographic and spectrographic work which has been done at the Yerkes and Mt. Wilson Solar Observatories within recent years.

"It is easy to see that you have begun that diagram at this end," said Sherlock Holmes, "for you have clearly tired as you went on, and I don't wonder. It was a long job!"

"On the contrary," replied the artist, "I began at the other end, and learnt how to do it properly as I went along."

Moral?—When you have the stars arranged in an evolutionary series, it may not be *quite* clear which is the youthful end?? ("From an Oxford Notebook" in *The Observatory*, January, 1917.)

Ephemeris of Comet *b* 1916 (Wolf).

[From Lick Observatory Bulletin No. 289. Received too late to be inserted in the department of "Comet and Asteroid Notes."]

1917, Gr. M. T.		True α			True δ		log Δ	Br.
Mar.	5.5	18h	16m	38s	— 1°	12′2	0.3502	1.00
	6.5		18	56	— 1	01.9		
	7.5		21	14	— 0	51.4	0.3441	
	8.5		23	33		40.7		
	9.5		25	52		29.8	0.3381	1.09
	10.5		28	11		18.7		
	11.5		30	31	— 0	07.5	0.3320	
	12.5		32	51	+ 0	03.9		
	13.5		35	11		15.5	0.3260	1.18
	14.5		37	31		27.3		
	15.5		39	52		39.3	0.3199	
	16.5		42	13	0	51.5		
	17.5		44	35	1	03.8	0.3139	1.29
	18.5		46	57		16.4		
	19.5		49	19		29.1	0.3079	
	20.5		51	41		42.0		
	21.5		54	04	1	55.0	0.3019	1.40
	22.5		56	27	2	08.2		
	23.5	18	58	50		21.6	0.2959	
	24.5	19	01	13		35.2		
	25.5		03	36	2	48.9	0.2899	1.52
	26.5		05	59	3	02.8		
	27.5		08	23		16.8	0.2839	
	28.5		10	47		31.0		
	29.5		13	11		45.3	0.2780	1.65
	30.5		13	35	3	59.8		
Mar.	31.5		18	00	4	14.4	0.2721	
April	1.5		20	25	4	29.2		
	2.5		22	50		44.1	0.2662	1.79
	3.5		25	15	4	59.1		
	4.5		27	41	5	14.3	0.2603	
	5.5		30	06		29.6		
	6.5		32	32	5	45.0	0.2545	1.94
	7.5		34	58	6	00.5		
	8.5		37	24		16.2	0.2488	
	9.5		39	50		32.0		
	10.5		42	17	6	47.9	0.2431	2.09
	11.5		44	43	7	03.9		
	12.5		47	10		20.0	0.2374	
	13.5		49	36		36.2		
	14.5		52	03	7	52.4	0.2318	2.25.
	15.5		54	30	8	08.8		
	16.5		56	57		25.2	0.2263	
	17.5	19	59	24		41.7		
	18.5	20	01	51	8	58.2	0.2208	2.43
	19.5		04	18	9	14.8		
	20.5		06	45		31.5	0.2154	
	21.5		09	12	9	48.2		
	22.5		11	39	10	04.9	0.2100	2.62
	23.5		14	06		21.7		
	24.5		16	33		38.5	0.2047	
April	30.5	20	31	16	+12	19.6	0.1892	3.01

Brightness 1917 May 5.5 = 1.00. In the ephemeris of *Bulletin No.* 286 the unit of brightness is that of 1916 May 10. With this as the unit, the brightness for 1917 June 1.5 is 79.9.